INDIAN FOOD INDUSTRY

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A PUBLICATION OF ASSOCIATION OF FOOD SCIENTISTS AND TECHNOLOGISTS (INDIA)

EXTRUSION COOKING
TECHNOLOGY

Farm Dryers

Engineering Systems for
Convenience Foods

Poly-β-Hydroxybutyrate:
Biodegradable
Thermoplastic

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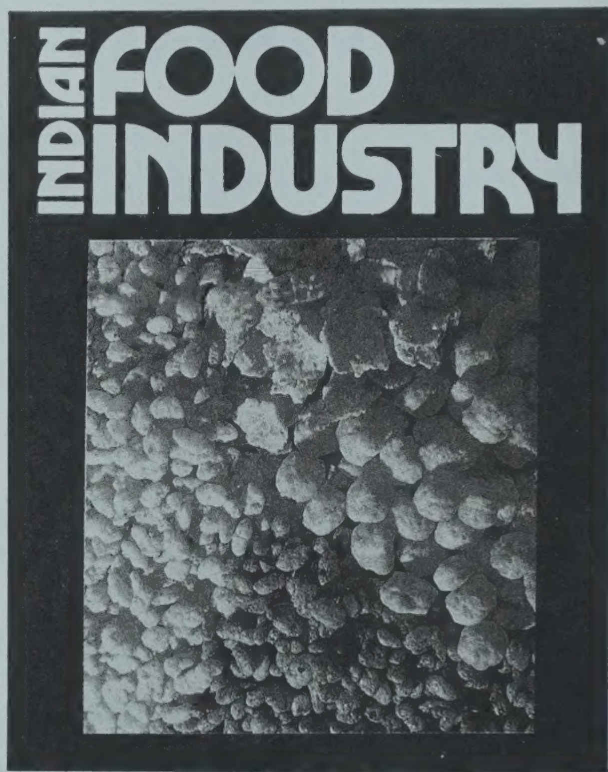

Photograph :
Extruded Products

Courtesy :
Neil Frame APV

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Review articles, technology papers based on R&D work and reports on various aspects concerning food industry are welcome from food scientists and technologists from industry, research institutions and other related organisations. Contributors are advised to provide good quality illustrations in the form of charts and photographs along with the manuscripts. The Editorial Board reserves the right to edit the manuscripts in order to make them suitable for publication in the journal.

Food industries may send information (suitably illustrated with photographs) about their new products, machinery, business ventures and other developments, which will be published on the discretion of the Editorial Board.

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FROM THE CHIEF EDITOR'S DESK

Most of us are familiar with that interesting 'panchatantra' fable of a man, his son and their donkey. The moral is - do the right thing and heed to no external opinion. In reality, it would seem that this moral is more easily stated than observed. The tantalising questions are what is the right thing to do in a certain situation and should the external opinion be totally unheeded. Indian Food Industries might be in a predicament of this kind groping to determine the right path to take. Without doubt, basic motivation for the industry is sustenance and growth. But, external opinions come barging in from governmental policy makers, academia, sociologists etc., not too infrequently coloured with lop-sided considerations. It would do good for Indian Food Industries to determine their own right path, keeping in view their interests and the nation's interests and not to seek sustenance and growth alone at any cost. India still appears a virgin field for exploitation of unique raw materials and exotic food products. So, why don't we look at these possibilities rather than trying to seek internationally well established products and processes ?

This sixth issue of Indian Food Industry now in your hands carries 4 interesting lead articles. The article by Nanjundiah and colleagues on Farm Dryers will be more relevant to the Indian situation and might reflect my thoughts expressed above on Indian raw materials. This journal had earlier carried articles on extrusion cooking. Smith and Singh present certain newer angles to this process and provide updated information on extrusion cooking. Devariya's article on Process engineering systems is focussed on convenience foods for the armed forces, but could be adapted to the general public as well.

As the new Chief Editor of your Indian Food Industry journal, I am privileged to thank all my predecessors and their team of editors and advisors who have elevated the journal's quality to what it is now. I am yet to contribute my own mite.

Richard Joseph
Chief Editor

INDUSTRY NEWS

Price of Levy Sugar Raised

The Government has raised the price of levy sugar for the Public Distribution System (PDS), from 9.45 per kg to 10.50 per kg. The decision is diametrically opposite to the slash in the levy price of wheat, from Rs. 4.02 per kg to less than Rs 3 per kg. The reduction in the price of wheat will cost the exchequer much more than the money likely to be raised through the hike in levy sugar prices.

'Pure Drinks' Seeks Legal Intervention

The Rs. 42 crore 'Pure Drinks' appealed to the Delhi High Court for an injunction, restraining Cadbury Schweppes from limiting Pure Drinks' distribution rights to only Delhi. The petition challenged the legality of Cadbury Schweppes' decision to restrict the growth of Pure Drinks' distribution business.

RBI Projection of GDP

The Reserve Bank of India (RBI) has projected a gross domestic product (GDP) growth of 6.8% during 1996-97' but has expressed concern over the slowdown in industrial and export growth rates and the high interest rates. The index of industrial production grew by only 9.8% during April-September 1996 compared to the 12.1% growth, it registered during the corresponding period of 1995. Exports in dollar terms grew by only 6.4% during the first nine months of this fiscal, down form 24.2% during the corresponding period of the previous year. In its report on currency and finance, the RBI called for an increase in the savings rate to sustain the projected rate of economic growth.

Budget'97 - A Major Package for Food Processing Industry

The budget '97 just might see a major package for the food processing industry. If that happens, that will be the outcome of McKinsey officials presenting the management consultancy firm's report on the food processing industry to the finance ministry.

McKinsey executives underscored the high tax rates that common food items are subject to (for example, a 33% tax is levied on biscuits). They also stressed that cold chains are essential to store not just luxury items such as ice-cream but also essentials such as milk, that the tax on cooling equipment was high and that the food processing industry in the country had a huge potential. Evidently, the numbers cited at the McKinsey presentation were a revelation to the gnomes at the ministry too.

Cadbury's to Launch New Products

Cadbury India Ltd is set to bring its Indian product portfolio more in line with its UK-based parent's. Coming up in the next six months will be an array of sugar confectionery. Googly, a hard-boiled sugar sweet has already been launched in Tamil Nadu and the company plans to take the product national soon. Meanwhile, Cadbury has announced a one-for-every-five-shares rights issue at Rs 150 per share.

Rs 45,000 Crore Investment in Food Processing on the Anvil

The Union food processing ministry has lined up projects worth Rs. 45,000 crores for investment over the next few years. As many as 4,000 memoranda of understanding (MoUs) have been signed and 15 per cent of these projects has already been implemented. According to the ministry sources, about Rs. 4,000 crore worth products involving food and agro-processing have started commercial production.

France Offers Latest Wine Technology to India

France has offered India its superior wine manufacturing technology so as to fully exploit its wine producing potential.

French commercial attache in India Bertrand Boncorps said that France was keen to share its advances in agro technology with India especially in manufacturing export-oriented wine and could share its technical know-how in sectors like seeds. food processing, preservation and packaging, as many as four leading French agro-based companies interested in entering the Indian market had been exploring the possibilities and trying to identify areas of joint venture.

Indian Tea for Iranian Market

Indian tea companies have bagged fresh orders of around 1,050 tonnes from Iran, taking the total in the past few months to 5,050 tonnes. This is considered to be a major breakthrough because India had not made any official exports to Iran in the four years since 1992, mainly due to the severe foreign exchange crunch faced by Teheran.

Iran which imports about 30,000 tonnes of tea annually over and above the 65,000 tonnes if produces locally, has traditionally been an important market for Indian tea.

UK Body Keen on Water Resources and Food Processing

Northern Development Company (NDC), a non-profitable business organization of United Kingdom, has shown keen interest in new sectors for the British to participate. The new sectors are water resources, pollution control equipment and food processing.

In the water sector, the British are willing to bring sewage management technology and also wish to operate in drinking water supply sector both for major cities and in the mineral water business. They expect a trade of around two to five million pounds in this sector in a couple of years.

Food processing is another area of interest. The British would like to have fresh fruit processed in India and then delivered to Britain. Even other food items like cakes and pastries can do some good business.

Chicken Egg's Problems

The poultry industry is one segment, which is always beset with some problem or the other. Either it is the fast rising feed costs or the egg and meat prices not up to expectations of the producers. Otherwise, there are too many players in the field, fighting for survival. According to industry sources, 15 to 20 per cent of the players fold up every year, but there is a continuous stream of newcomers to compensate.

And now the Finance Minister, Mr. P. Chidambaram's budget proposal to do away with the benefits available to the poultry industry under Sec. 80JJ of the Income-tax Act has come as a rude shock. For the last 10 years, one-third (sometimes 25 per cent) of the net profit from poultry activity was exempted and the remaining two-thirds only was subjected to income-tax.

But it has now been done away with on the ground that poultry had registered sufficient growth and subsidy was not necessary anymore. However, those in the filed point out that the per capita consumption of eggs and meat in India is way behind international standards. If we are to go anywhere near, the industry will have to grow a lot more. And it still needs incentives to do so.

Andhra Pradesh is the largest producer of eggs (3 crores a day) and 70 per cent of it is exported to other States. But during the last two years, the growth had slowed down to 5 to 10 per cent as against 10 to 20 per cent earlier because of rising feed costs and unremunerative prices, says Mr.M. P. Seshaiah, Director, Venkateshwara Hatcheries and President of the A.P. Poultry Federation.

The Indian per capital consumption is put at 33 eggs and 550 gm of meat as against the international standard of 250 to 300 eggs per annum and 25 to 30 kg meat. The National Institute of Nutrition (NIN) has recommended 180 eggs and 11 kg meat for Indian standards.

Interestingly, despite low levels of per capita egg consumption, demand is not rising as fast as it should. The main problem, is non-availability of eggs in rural areas, where consumption levels have to pick up considerably.

A Process for Producing 1,3-Propanediol for Sugar Route

A biological process for production of 1,3-propanediol (PDO) is being developed by Du Pont in collaboration with Genencor. The single step fermentation process uses corn sugar as feedstock. Laboratory scale studies have produced the polymer intermediate at an excellent yield. Using recombinant DNA technique, Du Pont has been able to engineer a number of bacteria and yeasts, which could produce PDO from sugar substrates. By collaborating with Genencor, Du Pont hopes to speed up the commercial scale production of PDO.

Du Pont is committed to developing polymers based on renewable feedstocks. If the process is commercialized, it will be the first commodity chemical to be produced using recombinant microorganisms. The PDO produced by this process could be used as a feedstock for polytrimethylene terephthalate (PTI), a polymer, with the same properties as PET, which could be made in existing polyester fibre plants.

CSIR Joins Hands with French Counterpart

The Council for Scientific and Industrial Research (CSIR) and its French counterpart, Centre National de la Recherche Scientifique (CNRS), have entered into a three year agreement to carry out joint research in frontier areas of science and technology, during a visit of a high-level French delegation led by Prof. Guy Aubert to seven CSIR laboratories to have first hand knowledge of the CSIR capabilities in research and development.

The areas identified for collaborative studies include genome sequencing and analysis, microbiology, new approaches to drug design and pharmacological studies on potential drugs, biodiversity and ecology, environmental technology and energy, oceanography and chemical sciences.

The accord, initialled by Dr. R. A. Mashelkar, CSIR Director-General and Prof. Guy Aubert, CNRS Director General, provides among other things for scientists or laboratories outside CSIR and CNRS also to participate in the joint projects.

It also envisages the constitution of a high-power "think tank," consisting of five top scientists from each of the two countries.

Molasses Helps Clean-up TNT

Naturally occurring pseudomonas bacteria that have a liking for 2,4,6-trinitrotoluene (TNT) are used to clean up TNT-contaminated soil in a process devised by Argonne National Laboratory (Argonne, III). A key feature is the periodic addition of molasses, which increases bacterial growth by roughly 10 times the normal rate. This increases TNT removal tenfold. The bacteria break down the TNT into non-hazardous materials, such as CO_2, fatty acids and butanediol.

A $4.5 million pilot programme has been conducted at Joliet Army Ammunition Plant (Joliet III.), a former producer of toxic and explosive chemicals. Contaminated soil was slurried with 85% water and treated in four 300 gal bioreactors. Molasses was added twice a week, and 10-20% of the volume was replaced with fresh slurry once a week. The estimated cost is $250-300/yd^3, or about the same as composting, compared with $400/yd^3 for incineration.

Ethanol Sensor Measures Beer's Alcohol Content On-line

The German research foundation Frauhofer Gesellschaft (Munich) has developed a hand held sensor that measures ethanol concentration in beer and other process streams in less than 5 minutes. This is a key advantage in brewing alcohol-free beers, as the fermentation has to be stopped, when the alcohol level reaches the prescribed German limit of 0.5 vol%. Current off-line enzymatic or chromatographic methods take up to one hour, by which time alcohol levels may have been exceeded.

The key to the device is that it uses non-amperometric electrochemical technique. The method is accurate to within 0.1 vol% ethanol. Ongoing refinements will reduce measurement time to less than one minute and an infermenter version is being developed. The first industrial use will be at a German brewery within a year.

A New Process for Poly-Aspartic Acids (PAAs)

Bayer has developed a new process for manufacturing polyaspartic acids (PAAs) from

maleic anhydride and plans to build a 2000 tonne/year pilot plant in the coming year. The new process is based on reacting maleic anhydride with ammonia. Rohm & Haas and Donlar (USA) are also reported to be developing processes for PAA production based on polymerization of aspartic acid. Bayer, however, claims that its route is much more direct and cost-effective.

PAAs are biodegradable compounds and are very efficient dispersing and sequestering agents, preventing sedimentation in aqueous dispersions of slurries. They can prevent deposits forming in cooling circuits or in boiler or feed water treatment. They are also dispersing and softening agents for detergents in petroleum extraction. Bayer is planning to build a full scale plant of 25000-30000 tonnes per year capacity at its Leverkusen headquarters in Germany.

A Versatile Anionic Surface Active Agent Based on Disulfonates

The Dow Chemical Co. has recently introduced a highly soluble disulfonated surfactant known as Dowfax Detergent Solution, which Dow claims can significantly incorporate linear alkylbenzene sulfonate (LAS) into a variety of cleaning formulations, including rug cleaners, hard surface cleaners and dish and laundry detergents. According to Dow, the new product is an alkylated sulfonated diphenyl oxide disodium salt. The molecule consists of a pair of sulfonate groups on a diphenyl oxide backbone, a structure that results in a powerful, durable and verstile anionic surface active agent.

India - 5th Largest Economy in PPP Terms

India is now the world's fifth largest economy in terms of purchasing power parity (PPP) estimated at around $1,318 trillion, according to latest World Bank figures.

The "World Bank atlas' for 1997 released by the World Bank President, Mr. James, D. Wolfenson, ranks the United States, China, Japan and Germany ahead of India in terms of purchasing power.

India's PPP is given as $1,400 per capita against $ 340 calculated by conventional methods, translating rupees into dollars at the prevailing rate.

The World Bank President also released the 'World development indicators" which for the first time added Pakistan to the list of 'emerging giants". The list also includes China, India, Brazil, Russia, Mexico, Argentina, Indonesia, Turkey, and Thailand. However, according to the World Bank's new vice-president and chief economist, Mr. Joseph E. Stiglitz, the statistics were derived from various sources, not all of them too reliable.

Officials of the bank pointed out that India's PPP figures, a dismal $30 ahead of Bangladesh, were based on data supplied by the government a few years ago, which had been adjusted according to the growth rate.

Dereservation of Small Scale Industries

The Abid Hussain committee on small enterprises recommended a complete dereservation of the small scale sector. It also suggested removal of the ceiling on foreign investment and raising the investment limit for small scale sector. It also suggested removal of the ceiling on foreign investment and raising the investment limit for small scale industries (SSIs). The committee, which submitted its recommendations to the Ministry of Industry, maintained that the changes recommended were consistent with the paradigm shift that has already taken place in the economy. At present, 68 items are reserved for small units, which accounted for 80 per cent of the total value of the SSIs production.

Food Safety Norms Under HACCP

Indian processed food exports to the US and the European nations may meet the fate of 'inflammable skirts" or certain dyed textiles, which were held up or banned abroad as hazardous, if they do not meet the safety norms under the HACCP (or the hazard analysis critical control point) by the end of 1997.

Australia, Canada and New Zealand are also in the process of fixing similar deadlines for their food imports to meet HACCP norms, according to the Director of the Centre for Processed Foods, Mr. G. Asvathanarayan, and Mr. P. C. Nayak of the Centre for Technology Development, Bangalore.

This is an emerging management system comparable to ISO 9000 to ensure safety and hygiene in the food industry. The insistence on HACCP standards will have major economic implications on India, which has a growing food processing industry. But, the fact is little known and Indian exporters may be caught unawares

according to Mr. Nayak and Mr. Asvathanarayan.

HACCP includes identification of chemical, physical and bacterial hazards in raw materials and processing methods. The dangers could be from metals, bones, pesticides, chemicals, or *salmonella* and other organisms present at certain stages. Through HACCP, the industry would find the critical or unsafe points and control them.

Mr. Asvathnarayan said HACCP would become a global standard for fruit, meat and other processing industry. So far, only a minority such as the Marine Products Export Development Agency and Hindustan Lever, had adopted for their products.

Britain's Export Potential of Food and Drinks

Exports of dairy products from the UK increased by 18% to reach 800 million, in 1995 with the Dutch importing one quarter of the total by value; other key markets included France, Belgium and Ireland. British chilled desserts, as sold by Marks & Spencer for example, have become the envy of Europe.

British cheeses continue to sell well in global markets including Japan and North America. Among exhibitors promoting them at the show was Ilchester Cheese Co Ltd of Somerset, southwest England, which has moved into the second phase of its purpose-built production unit over two years ahead of schedule.

Biscuits, bread and bakery are important exports too and British sandwiches have achieved considerable success in European markets. Britain remains the number one supplier of savoury snacks, based upon strong domestic consumption. Britian's consumption of biscuits is nearly double the European average, and exports are increasing rapidly. Perhaps the most dynamic trend is that of speciality ethnic breads such as Garlic, Arabic and Naan for which Britain is becoming renowned in international markets. Furthermore, the British are now the number one exporter of ethnic ready meals to Europe with exports approaching 200 million.

Britain exports 3 billion worth of drinks, the lion's share accounted for of course by whisky - the top selling spirit in the world with global sales of 2.3 billion. Widget technology for beer and new brands of alcoholic carbonate drinks have also fuelled growth, and soft drinks too have shown remarkable sales thanks to product innovation. The Americans in particular are thirsty for British beer and several British companies are exporting mineral water to France.

Courtesy : British Deputy High Commission, Chennai.

Sophisticated Frozen Foods

British frozen foods generally are now sought after by overseas buyers, Britain having one of the most sophisticated frozen food markets in the world. Fish and Seafood products including ready meals and convenience products valued at £ 691 million were exported in 1995. Albert Fisher Group plc's Seafood Division has recently opened sales operations in France and Germany and at SIAL in Paris launched its first pan-European brand, Ocean Bistro.

The UK is now the number one exporter of shellfish in Europe, providing well over one fifth of all supplies. Traditional fish products also do well, and last year the UK exported nearly 5 million of fresh salmon to Japan alone.

Traditional Dishes - Without Meat

Birds Eye has launched Meatfree, a range of dishes made from blends of soya, wheat and pea proteins, seasonings and herbs. The range consist of traditional-style meals - Sausages, Garlic and Herb Grills, Chunky Burgers and Cottage Pie - designed to occupy the slot traditionally occupied by "meat and two vegetables" at the evening meal. According to Birds Eye, an independent survey has revealed a clear trend for cutting down meat among the British population.

Cadbury Schweppes Signs MoU with NEERI

M/s Cadbury Schweppes Beverages India Pvt. Ltd (CSBIL), Mumbai, have entered into Memorandum of Understanding with the National Environmental Engineering Research Institute (NEERI), Nagpur, on 14 January 1997, for delineation of environment strategy and management policy in line with CSBIL's international guidelines; environmental impact and risk assessment of CSBIL facilities and its bottlers; liquid waste management with focus on recycle/reuse through environment - friendly technologies; product quality monitoring at the national level for soft drink and bottled water; conservation and management of energy resources; and total environmental quality management.

Nestle's Launches a Soft-centred Sweet

Nestle India, which has just launched a soft-centred sweet called Allen's Splash, intends launching as many as 27 products-including extensions and new pack sizes - in 1997. Allen's Soothers lozenges and Maggi tamarind sauce are rumoured to be next. Others will also be either confectionery or culinary products - the two identified thrust areas.

CSIR and A.P. Oil Federation to Jointly Establish Oil Palm Processing Plant

A.P. Cooperative Oilseed Growers Federation Ltd, Hyderabad and Council of Scientific & Industrial Research, New Delhi, have entered into a Memorandum of Understanding for establishment of a 10 - tonne fresh fruit bunches per hour capacity oil palm processing plant, at a total cost of Rs. 112.0 million on turnkey basis, at Ashwaraopet, District Khamam, Andhra Pradesh.

The MoU signing function was held in CSIR Vigyan Kendra, New Delhi on 27, December 1996 under the presidentship of Dr. R.A. Mashelkar, Director-General, CSIR.

The special features of MoU are as follows :-

Role of CSIR

(i) CSIR would implement the project on turnkey basis through licensee project engineering companies including supply, erection, equipment, machinery and commissioning of plant.

(ii) CSIR would arrange training of personnel of A.P. Oil Federation and CSIR in management, operation, maintenance and quality control of oil palm processing plants.

(iii) CSIR would adopt consortium approach for implementing the programme by co-ordinating the expertise and experience available in A.P. Oil Federation and CSIR laboratories.

(iv) CSIR would collaborate with A.P. Oil Federation to mobilize partial funding from various sources industry the Technology Mission on oilseeds and pulses.

(v) CSIR would guarantee the performance of the oil palm processing plant.

Role of A.P. Oil Federation

(i) A.P. Oil Federation would implement the civil works related to the project.

Shri S.D. Garg, Advisor and Head, Societal and Technology Mission Divisions, CSIR, New Delhi while welcoming the invitees to the function, highlighted the relevance of undertaking and implementing this large scale project, based upon technologies developed in CSIR for high impact and visibility. Dr. A.D. Damodaran, Director, RRL, Thiruvananthapuram in his opening remarks emphasized that technology development undertaken by his institute was tailered to suit the domestic requirements and stressed that Red Palm Oil has great potential to overcome vitamin A deficiency among children.

Shri N. K. Sharma, Managing Director, NRDC appreciated the initiatives of CSIR in establishing oil processing technology in the country.

Shri Dinesh Kumar, Managing Director, A.P. Oil Federation expressed hope and optimism that both CSIR and A.P. Oil Federation would work together with devotion for the establishment of a palm oil mill in Andhra Pradesh.

Shri K. Arya, Joint Director, Technology Mission on Oilseeds and Pulses lauded the role of CSIR scientists in developing oil palm processing technology which has provided a great boost to oil palm plantation programme.

Dr. R.A. Mashelkar, Director-General, CSIR while expressing happiness, remarked that this project heralds a new era in CSIR where R&D scientists, user industry, project engineering companies and technology development funding agencies would work together to achieve the cherished goal of establishing a state-of-the-art oil processing plant based on indigenous technology developed by CSIR laboratory.

Shri N. D. Seth, Joint Advisor, CSIR proposed a vote of thanks.

Now-Flavoured Mineral Water

Delhi-based Mount Shivalik industries, collaborator with Kirin Brewery of Japan and marketer of such beers as Thunderbolt, Golden Peacock and Torpedo, is currently conducting a feasibility study to gauge whether flavoured mineral water would sell well enough in India. According to Sanjiv Bali, executive director, "Aerated mineral waters, both plain and with flavours like peach and lemon, are being contemplated." He expects the products to enter the market by the end of 1997, priced about 10 per cent higher than Bisleri and other such labels. Bali rules out the domestic launch of Kirin beer in the near future.

New Applications of Extrusion Cooking Technology

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Introduction

Food extrusion is a versatile high temperature, short time (HTST) process which has become established for the continuous manufacture of new and traditional products. Extrusion cooking applications in the food industry today cover a wide range of food products based on starches, cereals, proteins and sugars. Extrusion cooking has the capacity to produce a large variety of products from numerous raw ingredients. It is often characterised by low production costs resulting from the small area required, reduced energy consumption and low numbers of personnel that are necessary. In this way , it has challenged traditional ways of fabricating food products and also satisfied the industry goal of new products. In many cases, the amount of added water can be reduced, which eliminates the costly evaporation of surplus water at a later stage in the process. It can also use cheaper feed stock than conventional processes. The extruder may also be described as a complex biochemical reactor and it is in this mode that the greatest scope for new development exists. Supercritical carbon dioxide extrusion is one of the more recent technological developments to broaden its portfolio of applications.

Equipment

The basis of extrusion cooking is a screw pump using twin or single screws. The single screw extrude is still used in industry and its origins are in pasta manufacture, which is a low temperature, high moisture process (Mercier and Cantarelli, 1986). The single screw extruder has a wide residence time distribution and is generally a poor mixer. The single screw extruder may be operated with a pre-conditioner, which may be used to add water either directly or as steam. There is, nonetheless, considerable interest in developing the single screw extruder as a modular design with mixing elements, such as the cavity transfer mixer. A greater variety of twin screw devices is a available with intermeshing or non-intermeshing co- or counter-rotating extruders. The counter-rotating intermeshing twin screw extruder is cited for use with low viscosity materials and generally operates at lower screw speeds than its co-rotating relative (Wiedmann and Strobel, 1987). However, the most commonly employed type is the intermeshing, co-rotating extruder comprising self-wiping, conveying and reversing elements, orifice discs and mixing paddles, which may be assembled to convey forward or backward. Liquids and other solid or semi-solid ingredients are often fed into the extruder at different stages along the barrel length. The twin screw extruder has the capability for good mixing and narrow residence time distributions. The versatile design of the screw means that the mixing stages can be synchronized with the temperature zones and the pressure may be designed to follow a complex history involving a section at atmospheric pressure in order to vent the extruder or to inject materials or gases (Fig. 1). The most recent development in extrusion technology is to combine

Food extrusion is a versatile high temperature, short time (HTST) process which has become established for the continuous manufacture of new and traditional products.

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it with pressures. The combined "supercritical fluid extrusion" process introduces the supercritical fluid, usually carbon dioxide, carrying soluble micronutrients, flavours and colours, into the melt stage of the extruder. It has been demonstrated for breakfast cereals, pasta and confectionery production.

A number of innovations are possible as the material leaves the screw section and passes through the die. Multiple dies may be designed with geometries to reduce pressure more or less rapidly to atmospheric. Co-extrusion in which a filler is pumped into the centre of a hollow extrudate has been popular for a number of years and has enhanced the product types available through this technology. The occurrence of flow defects and the viscoelastic nature of food materials dictates that the material exiting the extruder does not conform to the shape of the die. The loss of superheated water as steam has been the basis of many novel extruded products and in these cases, the extruded diameter is markedly greater than the die section. At its simplest, extrusion cooking may be used as a single stage process to produce pasta or expanded cut pieces. However, most extrusion technology is used with other downstream processes for rolling, crimping, cutting, toasting and coating (enrobing).

Further technological innovations are possible with the twin screw extruder in handling wet materials. The extruder may be used for multiple feeds such as dehydrated potato and potato mash (Fig. 2) (Ferdinand *et al.*, 1989). Similarly, nuts and fruit slurries may be added at appropriate points to avoid high shear or high temperature.

Cereal and Bakery Products

This is a traditional area where extrusion cooking has made the greatest impact. One of the original developments of the food extruder was to rival the pasta press. High protein wheat semolina is mixed to a dough with water and is then formed through dies, followed by appropriate drying. Related processes use maize or dehydrated potato, the latter often in combination with potato starches, to form collets or dense shaped pieces, which are dried and may be transported in this state of minimum volume. Expansion to create "third generation" snacks may be carried out using hot air, microwaves or frying, which rapidly heat the collet so that it softens and is expanded as water turns to steam.

The combined "supercritical fluid extrusion" process introduces the supercritical fluid, usually carbon dioxide, carrying soluble micronutrients, flavours and colours, into the melt stage of the extruder.

These products may also be manufactured by "sheet and cut" processes, which involve the formation of rolled sheets from which product shapes are cut. Directly expanded or "second generation' snacks and some expanded cereals are made by direct steam-expansion of the extrudates. The water in the food material dough or melt in the extrude is superheated, but flashes off as steam, when the pressure falls at the die. The food material is sufficiently plastic under elevated temperature conditions that it deforms. Cooling and loss of moisture cause the material to solidify in the expanded state.

One approach, which has been advanced to better understand extrusion processes is to take a biopolymer science approach, which considers the polymeric nature of starch and protein molecules (Slade and Levine, 1993). Polymers melt in the extruder under hydrated conditions and solidify, when they pass through their glass transition. A scheme of the changes in mobility during the process is shown in Fig. 3. The glass transition varies with water content and is also lowered by other small molecules such as sugars. The variation of temperature and water content in a schematic breakfast cereal process is shown in Fig. 4, from which it can be concluded that the initially solid material melts in the extruder, but remains sufficiently mobile in the flaking step to be flattened without breaking. Removal of further moisture on toasting, allows ductile deformation of the surface of the flake, causing blistering before the flake solidifies. The final flake owes its crisp or crunchy texture to this loss of mobility. From thermal analysis or calorimetry, it is possible to measure glass transition data for particular compositions (Georget and Smith, 1995).

Expanded ready-to-eat cereals are manufactured from mixtures of cereal flour and starch combined with small amounts of malt, fats, sugars and salt (Harper, 1981). Extrusion can be used to produce directly formed or expanded cereals and also as part of a total process, for example, for making cereal flakes. In the latter case, the extruder produces filaments of slightly expanded cereals which are cut, rolled and then toasted. The alternative process is pressure cooking combined with rolling and toasting (Fig.5). While pressure cooking uses whole grains, extrusion uses grits and flours as feedstock with consequent cost savings. It is clear that the extruder subjects the material to shear in a HIST operation, which contrasts with the conventional shear-less, comparatively

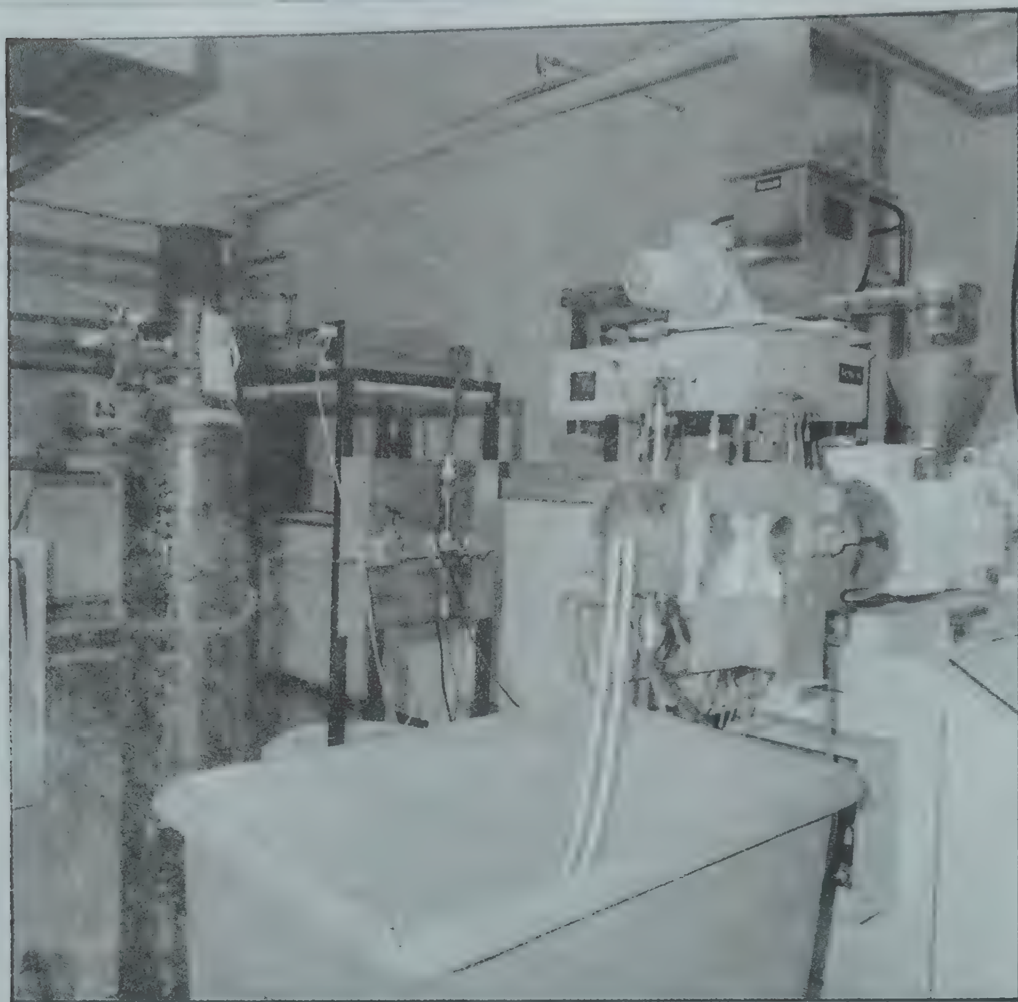

Fig 1. Werner and Pfleiderer Continua 37 extruder showing set up for gas injection

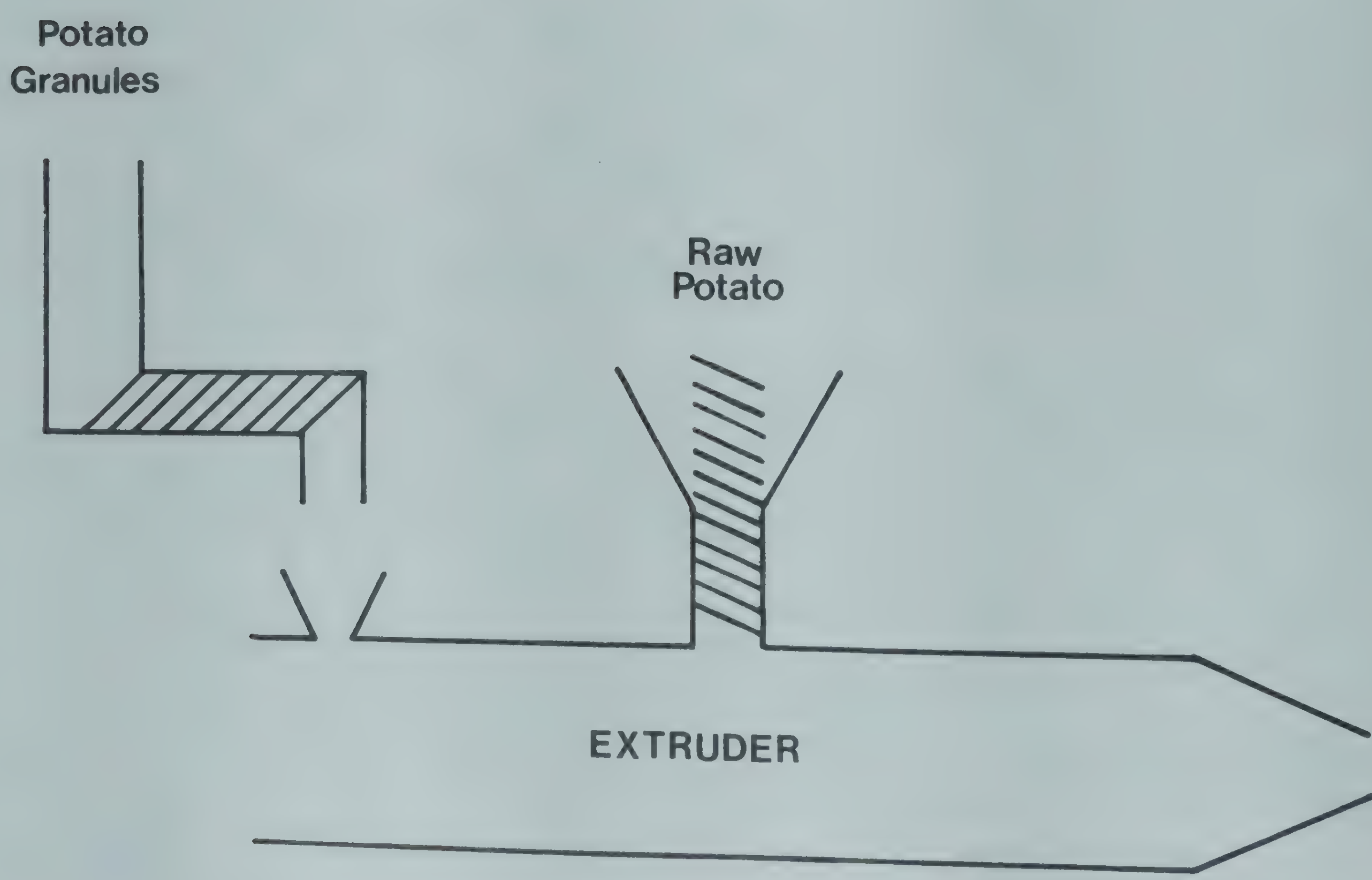

Fig 2. Scheme of co-rotating twin screw extrusion showing two feeds

long time process. The conventional and extrusion-based processes can be compared and contrasted at a number of structural levels, which underpin consumer properties in terms of flavour generation and texture, including subsequent bowl life in hot or cold milk. The microstructure of starch affects its solubility and expansion properties. In general, high specific mechanical energy extrusion results in destruction of starch microstructure leading to high expansion and high solubility (Smith, 1992). It is difficult to obtain highly expanded cereals, which have desirable low solubility, which reduces perceived stickiness of these products.

One approach to overcome the problem of expansion while low solubility is to operate an extruder under low temperature and low specific mechanical energy conditions and to use the injection of gas into the extruder barrel to solubilise it so that it is released, when the pressure falls on exit from the extruder (Ferdinand *et al.*, 1992). More recently, supercritical fluid extrusion (Rizvi *et al.*, 1995) has been developed to produce a structured product under low temperature conditions.

Crispbreads may be produced by extrusion cooking and these are formed into sheets, then creased so that they may be broken cleanly after drying and toasting. This compares with a traditional baking process.

The first part of the brewing process involves mashing of the malted cereal, which gelatinizes the starch and degraded into fermentable sugars by amylolytic enzymes. Malted cereals are relatively expensive and this leads to its supplementation by adjuncts. Extrusion-cooked cereals have potential as brewing adjuncts (Briggs *et al.*, 1986; Wiedmann and Strobel, 1987). Extrusion destroys the starch granular structure so that it is more readily hydrolyzed by enzymes in the mashing process. It has potential advantages over the use of cereal flakes in the high yield of fermentable extract.

Expanded rice cakes of fine structure can be produced by extrusion cooking compared to the harder texture and loner processing ties typical of conventional hot air drying. Extrusion cooked rice flour has also been reported to improve the quality of *Idli*, a traditional south Indian food (Singh *et al.*, 1995).

While pressure cooking uses whole grains, extrusion uses grits and flours as feedstock with consequent cost savings.

Corn - soy blends with optimized nutritional properties have been studied extensively, often using low cost extrusion technology (Harper 1981 ; Lorenz and Jansen 1980; Jansen and Harper, 1980). Extrusion can be used to treat starches and flours to alter their functional properties, particularly water holding capacity and cold and hot aqueous viscosities. Soup ingredients and infant foods are based on modified cereal and vegetable flours, which have a high cold water viscosity.

More recently, supercritical fluid extrusion has been developed to produce a structured product under low temperature conditions.

The extruded material is basically dried, cooled and milled. An alternative conventional process is drum drying, which involves metering the aqueous flour dispersion onto hot rotating drums. The water is vapourised and the flour films removed from the drums by scraping. Again, difference between the two processes may occur at the microstructural level. Drum drying is a traditional starch gelatinization process whereas the starch microstructure may be disrupted by shear in the extruder. The resulting flours may have very different solubility and rheological characteristics, when reconstituted.

Texturised Proteins

One of the early innovations of extrusion technology was to make fibrous meat analogues from soya, which were originally marketed as meat substitutes, but are more commonly used as meat extenders. Many of these extrudates need to be rehydrated before use. More innovatively, long cooling dies are used with extruders to produce structured meat analogues at higher moisture contents (Noguchi, 1989). Injection moulding of this material is also possible in an entirely analogous way to the process used to make thermoplastic products (Fig. 6). Whey proteins may be heat-denatured and textured using shear. The extrusion of animal proteins has also been discussed (Areas, 1992). The alternative processes use spinning processes. Wet spinning uses high pH solutions of proteins, which are spun into coagulating acid salt baths. Stabilization of the spun fibres may be achieved by heating or the use of cross-linking agents. Dry spinning involves drawing fibres from a protein melt followed by solvent evaporation.

Confectionery

Confectionery items are another important type of products from the extrusion cooking process (Best, 1994). Sucrose and glucose may be processed at

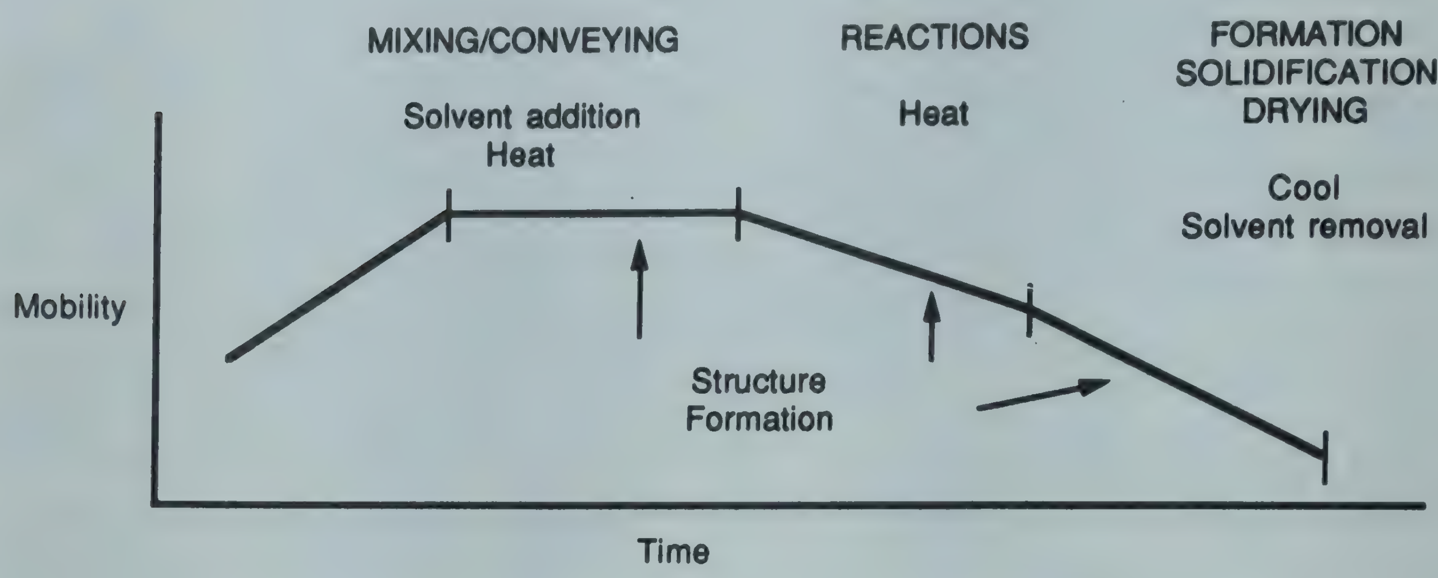

Fig 3. Change of molecular mobility during extrusion processing

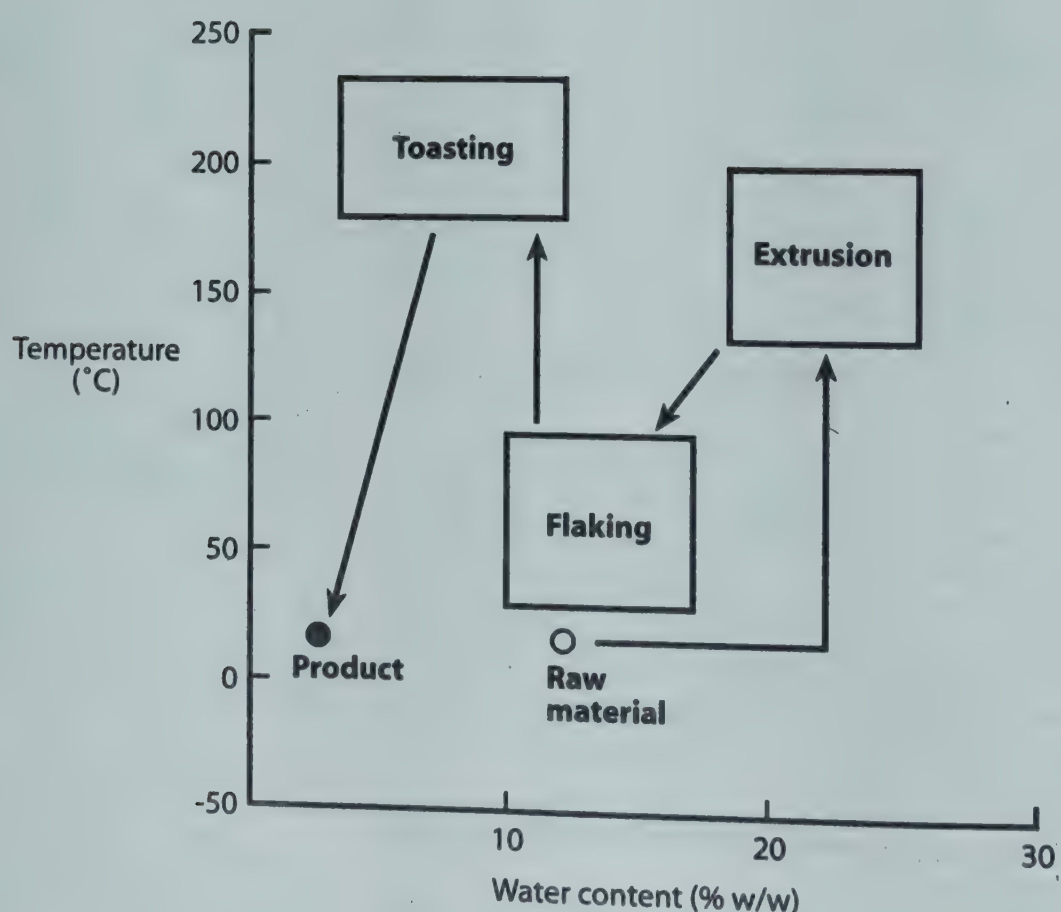

Fig 4. Stylised changes in the temperature and water content during extrusion based breakfast cereal production

low water contents to make boiled sweets and strands, making optimal use of the die shapes and co-extrusion. The residence time must be sufficient to allow melting of crystals and the temperature-time history must be short to avoid formation of off-flavours. The traditional approach involves the energy - intensive vapourization of large quantities of water. Liquorice and fruit gums make use of the venting capability of a twin screw extrude and the downstream addition of flavours and colours. Toffee, caramel and fudges of various types may also be made, replacing batch boiling pans. Aerated confectionery is also possible making use of gas injection.

Chocolate may also be manufactured using a twin screw extrude, making use of volatile removal and addition of cocoa nibs at the full length and of other ingredients nearer the die. The process removes off-flavours and provides sterilization followed by development of desirable flavours. Traditional chocolate production involves roasting of beans, grinding the cocoa nibs to form cocoa mass, which is mixed with cocoa butter and sugar over long periods to produce chocolate.

A related area is the use of the extrusion cooker to produce flavours, for example, by controlling Maillard reactions, roasting and caramelisation (Wiedmann and Strobel, 1987). A comparable process is drum-drying, but the extrusion process uses lower moistures. The Maillard reaction has nutritional implications in loss of available lysine and also changes the colour of an extrudate through non-enzymatic browning.

Extrusion cooking of chewing gum offers advantages of sustained release of flavour over traditional processes. The flavour is added early in the extrusion process to ensure adequate dispersive mixing with the base gum.

Animal Feeds and Pet Food

Extrusion cooking is an excellent method for combining waste feedstock of the production

Confectionery items are another important type of products from the extrusion cooking process.

of complete feeds. Fish and meat wastes are often combined with soybean meal. Fish foods with designed flotation characteristics are formed as flakes or pellets. Again, the microstructure may be manipulated to have the appropriate wetting and solubility characteristics to float or sink.

Petfoods production is a major product type of the ex-

Sucrose esters are powerful non-calorific fat replacers and extrusion cooking has been cited to implement the necessary chemical synthesis.

trusion cooking process (Rokey, 1994). They encompass hard dry varieties based on cereals, protein meals and fat to semi-moist types with added humectants. Co-extruded and multi-layered pieces and biscuits are refinements of the basic product.

The Extruder as a Reactor

Cationic starches are used in the paper industry because of their affinity with cellulose. Chlorohydrine reacts with starch in the presence of an alkaline catalyst. The highest degree of reaction occurs with the lowest water contents, which may only be achieved in extrusion cookers. Carr and Cunningham (1989) reported the formation of glycol glucosides, which are chemical intermediates in the production of urethane foams, from starch and ethylene glycol by twin screw extrusion cooking. Starch phosphates may be produced with a similar degree of substitution and less reagents, compared to the conventional method (Salay and Ciacco 1990; Chang and Lii 1992).

As much as 80% of the protein in milk consists of the casein complex. Separating casein from milk involves coagulation followed by purification and concentration by spinning and drying. Mildly acidic milk albumen becomes water soluble through neutralization with caustic soda. Extrusion cooking may be used rather than agitator vessels in combination with drum dryers and flaking equipment to form powdered caseinate (Wagner, 1989). Caseinate is used in baking and as a texturising agent.

Sucrose esters are powerful non-calorific fat replacers and extrusion cooking has been cited to implement the necessary chemical synthesis.

The use of thermostable alpha-amylase in the extrude and mixed with the estreated to liquefy and saccharify starches has been demonstrated (Linko, 1989), using alpha-amylase and glucoamylase. This has been suggested as a first step in ethanol production.

The possibilities of modifying other renewable resources to materials or ingredients with desirable and functional properties is a future area for growth of ex-

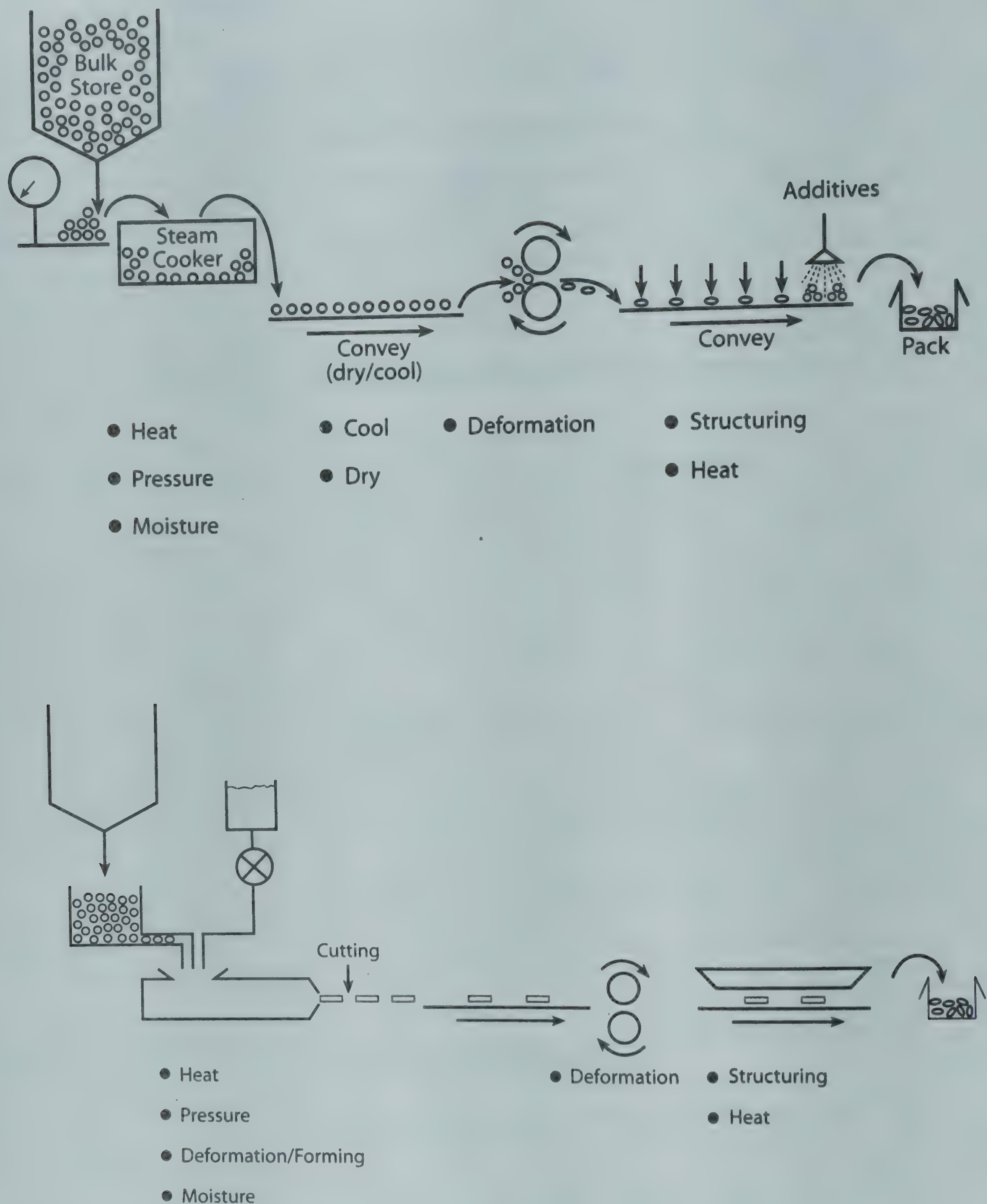

Fig 5. Schemes of a) conventional and b) extrusion cooking based breakfast cereal production

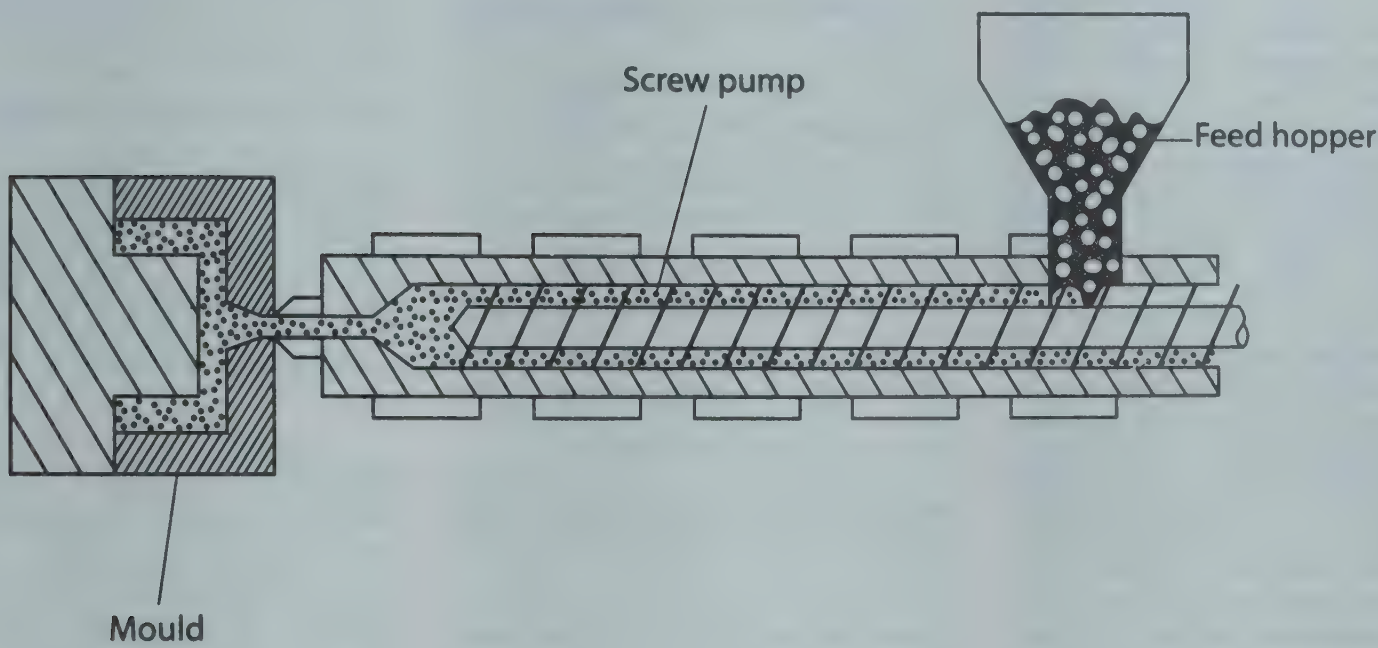

Fig 6. Scheme of an injection moulding machine

Fig 7. The APV Baker MPF 19 bench top extruder at IFR

trusion or related processes. Whole crop utilization is an aim of current work at IFR, which is examining vegetable waste by extrusion and other processes to provide useful functional ingredients. The extruder offers enormous scope to provide selective physical, chemical and enzymic breakdown of natural materials (Fig. 7). It is perhaps in this regard that the extruder has yet to make its greatest contribution to effect reactions, which rely less on chemicals.

Another application of extrusion cooking in the brewing industry is to treat hops to facilitate the transformation of bittering precursors to bittering components (Westwood, 1994). Hops are introduced into the wort boiling stage of the brewing process in order to impart bitterness to beer. Alpha acids present in hops, which are not particularly bitter or soluble in beer, undergo isomerisation into iso-alpha acids on boiling. The rate of isomerisation is increased under alkaline conditions and hence the extruder is used to react hops and alkaline salts with water addition.

Nutrition, Enzyme Inactivation and Sterilization

All heat treatment causes modification or loss of nutrients. In general, the high temperature of the extruder are destructive to some nutrients, but this is countered by the short time of the process.

Dietary fibre is defined by Asp and Bjorck (1989) as the polysaccharides and lignin that are not digested in the human small intestine. Processing affects the physical, chemical and physiological properties of dietary fibre. Extrusion alters the ratio of insoluble to soluble dietary fibre in favour of the soluble type.

Many food plants contain substances, which inhibit nutrient absorption and processes need to remove these anti-nutritional factors. Protease inhibitors are inactivated in the extrusion cooker, which increases the digestibility of proteins, although this is offset by loss of essential amino acids and cross-linking, which occur on heating. Lysine reduction is least at high extrusion moisture, but is comparable with that occurring in baking processes. The loss in protein nutritional value is of most importance in infant foods.

Legumes have substantial toxins and extrusion cooking of bean flour destroys anti-nutrient components and also improves palatability.

The young are very sensitive to antinutritional factors in soybeans and other seeds. Legumes have substantial toxins and extrusion cooking of bean flour destroys anti-nutrient components and also improves palatability. Beans contain lectins, trypsin and alpha-amylase inhibitors, which are inactivated and in addition, starch and protein digestibility is increased. Recent work at IFR has examined the incorporation of extruded bean flour, particularly from hard-to-cook beans, into African foods.

Starch is also modified chemically and physically in its own right for food and non-food uses and extrusion cooking is exploited for these purposes.

It is important that mineral availability should not be reduced by processing. Absorption of Iron and zinc does not differ between conventionally and extrusion-cooked starch-bran mixtures.

Most vitamins are process-sensitive and the extrusion cooking process destroys them in proportion to the process severity, as might be expected. Enrichment of extruded products with vitamins compensates for many of these losses.

Many enzymes in food may cause deteriorative reactions during storage, if they are not inactivated in processing. Lipase and alpha-amylase can be particularly thermostable, the latter being exploited in starch liquefaction. Extrusion of rice bran reduces the endogenous lipase. Oil extraction from rice bran was favoured by preliminary extrusion. In general, oilseeds can be efficiently pre-treated by extrusion cooking prior to solvent extraction. Lipoxygenase is also inactivated in full fat soybean extrusion.

Finally, although extrusion cooking may have an implicit sterilization effect, it may be used specifically for this purpose. For example, it has been used to sterilize spices (Gry *et al.*, 1984) and pharmaceutical materials. The heat-resistant bacterial spores of *Bacillus stearothermophilus* have been studied.

Non-food Uses

There is a growing interest in biodegradable plastics (Fanta *et al.*, 1980; Swanson *et al.*, 1993). Initially, starch was mixed with synthetic polymers in the original Griffin type processes. There is considerable interest in polyhydroxy butyrate and the addition of plasticisers like glycerol to imbue starch with more plastic, less brittle mechanical properties. Foamed loose fill packaging material may be produced by the

more conventional extrusion of starchy material as a competitor with non-degradable expanded polystyrene. Starch is also modified chemically and physically in its own right for food and non-food uses and extrusion cooking is exploited for these purposes.

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Farm Dryers for Preprocessing Applications In Food

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Abstract

A review of the current farm dryers used for agricultural products like cocoa, peanut, coconut and cardamom is presented. These products have to be dried in-shell in-situ due to inherent problems of transportation and processing. The main objective has been to highlight the necessity of an improved farm dryer, which is versatile and independent of power and fossil fuel requirement. With this in view, natural convection dryers already in application have been discussed in detail.

Introduction

Agricultural produce is harvested with a level of moisture content, not generally conducive for storage or transportation. Their deterioration occurs due to the development of moulds and fungi. These products are usually composite materials and methods of moisture reduction using sophisticated drying units may not be suitable from the economic and operational points of view. Since most of the agricultural production is from small holdings and situated in rural areas, it may not be feasible to use mechanical dryers, which necessitate unviable investment and operating costs.

Drying studies of these composite materials have shown that drying takes place mostly during the falling rate period. It has also been observed that the drying of these materials in-shell is advantageous to the two stage drying of in-shell followed by drying of kernal (Palipane and Driscoll, 1995). Hence, for these products, it is advantageous to use dryers with slow drying rates.

A number of conventional dryers have been developed for farm drying, which are cheap, versatile, low operational cost, suitable to local conditions and size of holding and also without the use of power drives.

The traditional drying methods adopted for copra in India are by a combination of solar and natural convection drying. Improvement of drying technology for getting a premium product especially in copra producing area in rainy and humid weathers is essential. Dryers using natural convection for air circulation are in use in pacific region (Thampan, 1988).

The present article covers the operating principles, merits and demerits of farm dryers using natural convection air currents as hot air source, which has the slowest drying rates.

A number of conventional dryers have been developed for farm drying, which are cheap, versatile, low operational cost, suitable to local conditions and size of holding and also without the use of power drives.

These may be classified as

a. Direct contact dryers; and
b. Indirect contact dryers

Direct contact dryers

These units are also referred to as 'Smoke houses', 'Barn dryers' or 'Bhatti system'.

Dryers of this type usually consist of a furnace and a contacting system for the hot gases and the materials. In its simplest and crude form, the smoke kiln consists of a pit or a fuel burning system,

where a cheap fuel-like wood, agricultural waste or husk is burnt. The flue gas passes through the bed of material supported suitably over the kiln. Fig 1 shows the model of such a kiln used for drying of copra in Sri Lanka (Aten *et al*. 1958). However, the construction varies with the differences in commodities to be dried. The material is raked at time intervals to get an uniform product. The kiln is usually provided with a Attap roof to avoid atmospheric contamination. The density difference between the hot air inside the dryer and the ambient air temperature is the main drive for the air circulation. The drying temperature usually ranges from 70^0C to 100^0C, depending on the product and the drying time varies from 2 to 6 days. These types of dryers are adopted for halved coconuts, groundnuts, coffee, cardamom etc.

The main demerits in smoke kiln is the existence of hot and cold zones (uneven temperature distribution) on cold nights and windy weathers, resulting in non-uniform products in spite of frequent raking of materials. The product has brownish colour with smoke and charred smell and a bad taste after drying. Due to non-uniform final moisture content, fungal infection occurs during the storage. Hence, they cannot be sold in standard markets. Reviews on these types of dryers have been published by Aten *et al*. (1958) and Ohler (1984).

Indirect dryers

To avoid the problems of high temperature due to the direct mixing of flue gas resulting in poor quality, the indirect contact dryers have been successfully used for many commodities. For achieving uniformity in product quality, it is essential to rake the material during drying. This is done manually in static bed dryers. An improved form of these dryers employs a rotating drum, which can be manually operated at frequent intervals for disturbing the material.

Static bed natural convection dryers : This is also called 'Curing houses'. This consists of a horizontal plenum chamber, a single large diameter metal tube, through which the combustion gas passes from furnace. The air surrounding this tube is heated and its density is reduced. The buoyancy currents are formed to force air upwards (McAdams, 1954) and through the material. The higher the plenum chamber, the more efficient will be the conversion of dynamic to static pressure and hence larger will be the overall flow of air through the crop. These dryers have been extensively used for cocoa, coconut, groundnut and cardamom.

To avoid the problems of high temperature due to the direct mixing of flue gas resulting in poor quality, the indirect contact dryers have been successfully used for many commodities.

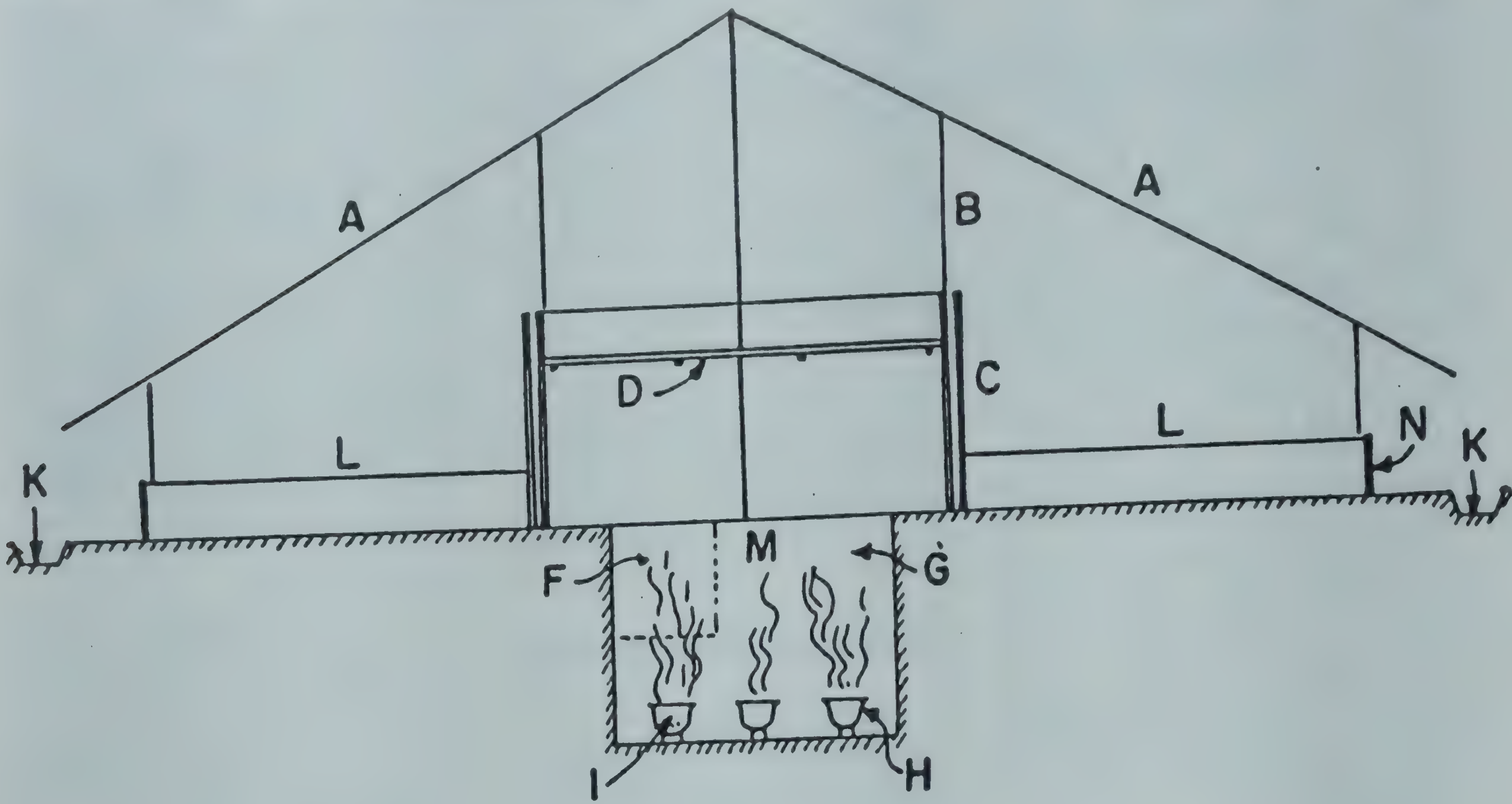
McDonal and Freire (1982) have reported the performance of a natural convection dryer for cocoa with a capacity of 2.7 tonnes per batch. The moisture content was reduced from 50% w.b. to 7% w.b in 50 to 60 hours using an air temperature of 70^0C to 75^0C. It is also reported that the plenum height has not much bearing on the drying rate. Sufficient ventilation for the exhaust air has to be provided to avoid condensation of moisture on the roof, especially during initial periods of drying. It is reported that wind speed outside the dryer has to be taken care in the design and layout of natural convection dryers.

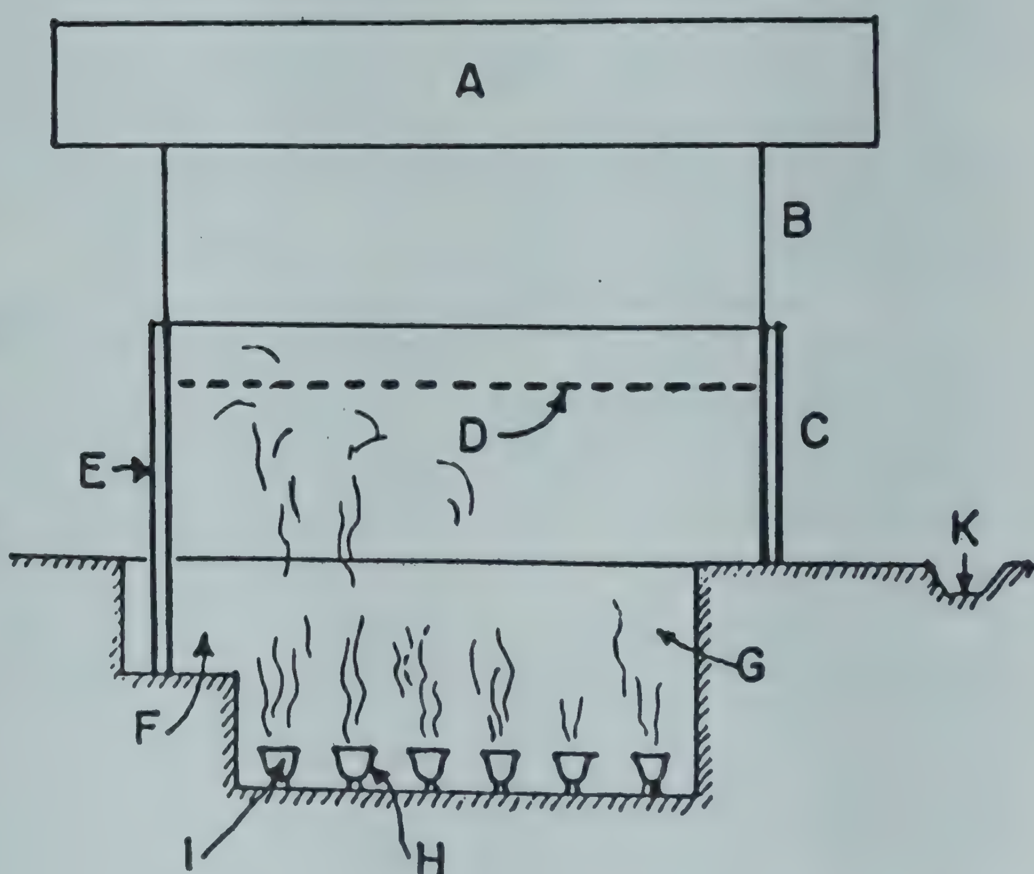
Patil (1989) has reported the application of a natural convection dryer for drying arecanut. The moisture content was reduced from 70% w.b. to 7% w.b. with a capacity of 150 kg batch size. The total drying time was 10 days with an air temperature of 80^0C. On comparison with solar drying, the appearance of product quality was good with minimum breakages, using natural convection dryer. It is concluded that natural convection dryers are economical than open solar dryers.

From a comparative study of 25 varieties of soybean, Ginner *et al*. (1994) have reported that it is preferable to dry at moderate air temperature of 60^0C to avoid structural, chemical and biological changes to the grains and also the risk of fire.

The demerits of this dryer are that the natural convection currents cannot generate very strong air flows and hence the material bed height should be shallow to reduce the resistance to the air flow. Also, high humidities of exit air leads to condensation of moisture inside the dryer if proper care is not taken in the design of flue gas distributors. The temperature distribution is also poor in many curing houses and a temperature gradient of 15^0C exists between upper and lower decks. Direct radiation from the furnace heats up lower parts of the interior walls leading to uneven temperatures.

Rotary type natural convection dryers : For improving the performance of static bed natural convection dryers, the rotary types of units in which bed is disturbed at regular intervals by rotary motion of the bed have been developed. The construction of a typical unit is shown in Fig. 2 and it essentially consists of a cylindrical sleeve, through the axis of which a duct passes. This duct is connected to the furnace. The sleeve is provided over the duct to avoid





A. Attap roof
B. Bamboo strut
C. Double wall of split bamboo
D. Grate of bamboo or ribs from palm leaves
E. Door to fire pit
F. Entrance to fire pit
G. Fire hearth
I. Flower bowls with shell charcoal
K. Drains
L. Working sheds
M. Smokeless hot air
N. Low wall of bamboo

(G.C.W. Chr. Tergast, 1937)

Fig. 1. Sectional Sketches of the Charcoal-fired Oven

direct contact of the hot duct with the material. Raw material is loaded in the annular portion of the drying chamber. The unit has a capacity of 25 kg of wet material per batch. The unit is manually rotated at intervals of 15 minutes to facilitate proper mixing of the material.

For improving the performance of static bed natural convection dryers, the rotary types of units in which bed is disturbed at regular intervals by rotary motion of the bed have been developed.

The drying time has been brought down from 26 to 10 and 20 hours, using air temperatures of 120^0C and 80^0C respectively during the drying of large cardamom. The quality of material dried at 120^0C was poor with respect to colour and volatile oil. But the material dried at 80^0C was good.

These units have limited capacity and have performance limitations by way of manual rotation for higher capacities.

Improvements to the present systems

The present systems can be improved by incorporating some new features and changes in the operating procedure, which will enhance both product quality and economy. One such study was conducted by CFTRI for drying large cardamom.

Bhatti system

Improvements to the system : The radiation losses through the open side of the kiln are very high and this can be prevented by providing a shutter. A chimney is to be provided to vent out smoke from the kiln. A metallic hood, underneath the wire mesh platform will prevent direct contact of the agricultural produce with fire. The hood radiates the heat upwards, thereby heating the product. By closing the open side of the kiln, radiation losses can be reduced and a convection current can be set up below the wire mesh.

Improvements to operational methodology : The loading rates presently practised are very high. Farmers tend to load higher quantities during a batch in order to

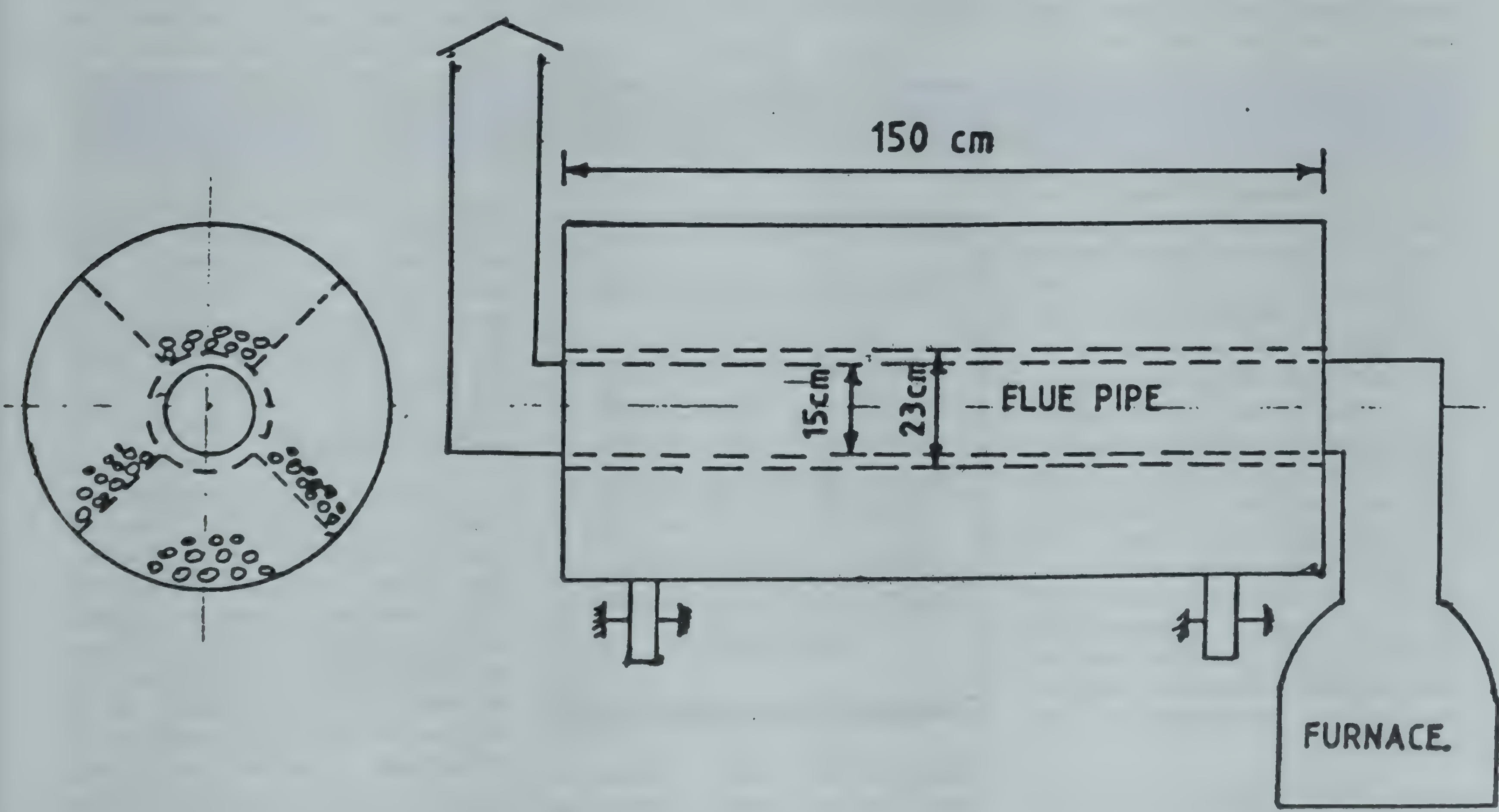


Fig. 2. Rotary Dryer

expeditiously complete the drying. However, optimum tray load must be maintained in order to get the best results. Products will have uniform final moisture contents due to scientific approach. Indirect heating and venting of the smoke from the kiln improves colour of the *bhatti* cured samples. These modifications can be effected with minimum expenses.

Development of a new natural convection dryer at CFTRI

To develop a new system for drying, the capital cost is very important. A low cost dryer to meet the requirements of the farmers, whose holdings are of medium size, was developed by a group at CFTRI. The essential parts of the new dryer are a furnace, rectangular flue ducts, wire mesh platform and supporting structures. The flue ducts are arranged in a double deck fashion and wire mesh platform is fixed above the ducts. The flue ducts are connected in series to the furnace. When hot flue gases pass through the duct, convection currents are set up below the platform over which the material is spread. The convection currents pass upwards through the bed of capsules allowing it to dry like a through flow dryer. The performance of this new system was evaluated in the drying of large cardamom at site.

From the trials conducted, it was noticed that the drying rate of the material in the upper deck was low and the thermal efficiency of the dryer was also low. The material was to be transferred from the top deck to the bottom deck in the final stages to complete the drying. Hence, the dryer was further modified to facilitate uniform temperature distribution in the dryer.

The modified dryer has two ducts in parallel to the furnace so as to get same temperature in the lower as well as the upper decks. The outlet air temperature from the two decks was same, indicating equal rate of drying in the two decks. The product quality was found to be equal to that from curing house. The modified natural convection dryer can be employed in medium-sized holding where, at present, 200 kg capacity curing houses are used. Also, the cost of drying is cheaper and could be popularised at the farm level. Fig. 3 shows the layout of such a modified dryer.

A low cost dryer to meet the requirements of the farmers, whose holdings are of medium size, was developed by a group at CFTRI.

Thermal efficiency of natural convection dryers : Generally, firewood is the fuel used for natural convection dryers. Initial heating of the system consumes much fuel and careful control of operation of the chimney and the fire hearth reduces the fuel consumption by more than 50% (Brooks, 1963). Selection of suitable insulating materials and operating schedules are essential for maintaining high fuel efficiencies. In case of copra drying, coconut shells have been reported to give a consistently uniform temperature (Aten et al. 1958). In a study on a cocoa dryer, McDonald and Freire (1982) have reported a thermal efficiency of 12 to 18%. They have stated that the overall efficiency can vary due to variations in flow induced by environmental conditions.

Table 1 gives the reported data on the fuel consumptions of various dryers and Table 2 gives the comparative performance evaluation of three types of dryers in the drying of large cardamom from the studies conducted by CFTRI team.

It is clear from the performance evaluation studies, modified static bed natural convection dryer developed by CFTRI could serve as an economical farm dryer for many products.

Future Research Directions

Data on design and scale up parameters are very scarce in literature. Also, evolving a judicial schedule of operation of these dryers will highly improve the product quality and thermal efficiency. The improved natural convection dryers developed should be versatile to accommodate most of the agricultural produce. The design should be based on sound engineering background along with basic drying theories. Research in this direction will facilitate a low cost, universal farm dryer to small and medium holding farmers.

Conclusions

It is clear from the performance evaluation studies, modified static bed natural convection dryer developed by CFTRI could serve as an economical farm dryer for many products. Efforts should be made to propagate this approach at farm levels on a cooperative basis for the benefit of all farmers. This will lead to the improved product quality and provide an economical alternative to mechanical dryers.

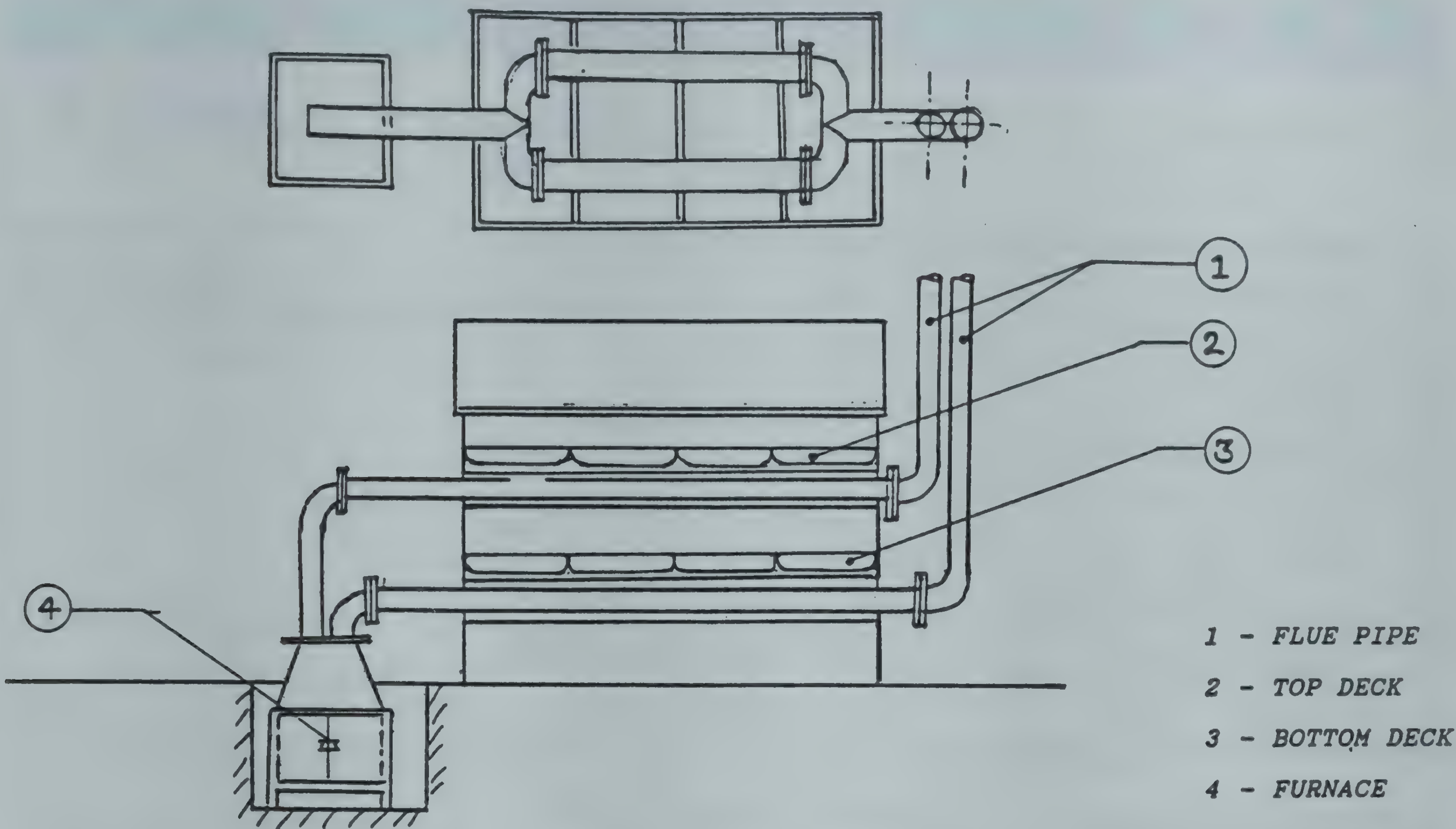


Fig. 3. Natural Convection Dryer ; CFTRI Design

Table 1. Performance Data of Natural Convection Dryers (Indirect contact)

Material	Groundnut	Cocoa	Coconut	Large	Cardamom*
Drying area (m^2)	7.53	36	148.5	16	62
Capacity (kg)	500	2700	2100	200	800
Drying time (hrs)	22-25	50-60	22-23	36	36
Drying temp. (C)	50-70	70-75	60	50	50
Initial moisture content (% w.b.)	35	50	58	80	80
Final moisture content (% w.b.)	10	7	6	10	16
Fuel used	Wood	Wood	Wood	Wood	Wood
Fuel consumption (kg/kg water removal)	3.95	6.11	-	0.875	0.875
Thermal efficiency (%)		14	-	2	8
Reference	a	b	c	d	d

a. Brooks, (1963), b. McDonald and Freire, (1982), c. Aten *et al.*, (1958), d. CFTRI, (1994).
* Small capacity of 200 kg and community curing centre 800 kg

Table 2. Comparative Performance of Farm Dryers for Large Cardamom*

Type of Dryer	Bhatti Curing House	Modified Dryer	CFTRI
Drying area (m^2)	5.3	27	9
Batch capacity (kg)	1200	350	300
Tray load (kg/m^2)	230	12.5	33
Average drying time (hrs)	36	35-40	24-26
Air temperature (C)	100-110	50-55	70
Fuel consumption per batch (kg)	3000	1600	800
Thermal efficiency (%)	5.8	3.2	5.3
Cost of drying per kg of product (Rs)	11.75	22	16.5

* CFTRI, (1994)

Acknowledgements

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Process Engineering Systems for Convenience Foods for Armed Forces

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Introduction

This article is an attempt to present various indigenous process systems available to extend the shelf life of convenience /snack foods of interest to armed forces. They are commonly classified as follows :

Types

Solid Foods

Freeze-dried products, Bakery items, Confectionery, Milk powder, Egg powder, *Chapatis*, Candied fruits, Spiced snacks, Canned meat, Dry fruits/nuts.

Concentrates

Jams/jellies, *Shrikhand*, Condensed milk, Yoghurt, Ready-to-cook retortable foods, Curries, Fruit pulp concentrates.

Liquids

Sterilized milk, Fruit juices, Soups.

Packing

Solid Foods

Light weight individual packs in moisture barrier enclosure.

Concentrates

Cans/retrotable pouches/sterile packs.

Liquids

Sterile packs, Cans, Bag-in-box.

Machinery for all these systems of standard design, material and construction are extensively produced within the country and are operating successfully.

Process Systems

The process systems involved in the production of shelf stable convenience foods/snacks can be grouped as:

Cold Chain Process

The cold chain process includes the following techniques :

Chilling, Freezing Freeze-drying, Cold storing, Cold transportation.

The cold chain process is energy intensive and involves very special packing, storing and transportation technologies - not practical for field situations of defence services. The exception is freeze-dried products in the context of their suitability for ambient storage and normal packing, though it is also an energy intensive process.

Thermal (Heating) Processes

Thermal processes include the following techniques :

Pasteurization, Sterilization (asceptic processing), Retorting, Canning, Extruding, Roasting, Frying, Evaporating, Drying.

Raw material preparation

The quality of the raw materials and preparation steps play an important role in the end product. Whatever be the process technology, all food process sys-

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tems need start with preparatory steps of raw material cleaning, grading, washing (where necessary), splitting/cutting and conveying - Machinery for all these systems of standard design, material and construction are extensively produced within the country and are operating successfully. However, in fruit processing industry in India, fruit cutting is manual. Advanced technology of mechanized fruit cutting systems is available from abroad. The technology is very relevant to India from point of hygiene for food processes. The author is in the knowledge of these mechanised fruit cutting systems, manufacturing and servicing of which are within the competency of Indian industry. Such technology is economically viable for processing a minimum 100 tonnes of fruit per day. Another preparatory stage of operation is of design and use of fruit ripening systems - very relevant in banana *puree* production and adaptable to other short season tropical fruits like mango etc.,

Cold Chain Systems and Indian Engineering Competence

Cold chain processes offer the best of product quality, flavour, texture, taste and nutrients. Basic precautions of packing unspoiled raw material, minimum treatment of pasteurization and proper packing are the essential requirements. However, it is obvious, all 'cold' products need to be preserved at 'cold temperature' all through its storage, transportation, distribution and consumption stages, which is an expensive proposition in tropical countries.

The process of cooling/freezing is achieved by vapour compression systems,using halocarbon and ammonia refrigerants. In India, 'Ammonia' sysytems are in extensive use for food refrigeration - both of the single stage compression design for conventional storage temperatures as well as multi-stage compression systems for 'Deep freeze' temperature conditions. There are more than four refrigeration compressor systems manufacturers who can provide ammonia and halocarbon plants, with proven experience in our country. From global 'Ozone Layer' retention considerations, type of halocarbons to be used should be carefully selected. Secondary coolant systems - which use brine, glycol coolants are supplementary to vapour compression systems to serve special cooling processes and/or low temperature applications. Indian refrigeration industry is well equipped to offer these systems. A third source for refrigeration is expendable refrigerants like dry ice, carbon dioxide, liquid nitrogen, helium etc., which have special relevance to instant hygienic food cooling and convenient mobile cooling systems like transportation of food. Some of these refrigerants have extensive applications in 'Cryogenics'. These refrigerants are available in India, though extensive availability and their distribution network requires substantial investments. It is believed, subject to 'Large scale production' of these fluids, these systems should be economically viable, if all aspects of system advantages and special features are considered. For this system, some "Refrigerant spray control" equipment only needs 'imports. Bulk transport/storage reservoirs production facility is available in India.

There are more than four refrigeration compressor systems manufacturers who can provide ammonia and halocarbon plants, with proven experience in our country.

Product Coolers

In addition to refrigeration sources 'Heat extraction' or 'Cold infusion' equipments have special design needs for Food Industry. They are available in the following forms :

Cold air systems : These serve the purpose of circulating and cooling air over 'cold' refrigeration coils, which cool the product and return to cooling coils. These equipments are available in India.

Contact coolers : Like plate heat exchangers, shell and tube coolers, plate freezers efficiently cool/freeze products. These coolers in design and material suitable for 'Hygienic Food Refrigeration' are made, used and proven in Indian food industry.

Immersion cooling systems : Liquid nitrogen or liquid carbon dioxide, to achieve 'Quick cooling/freezing' by direct contact is in extensive use in Food Industry in Western World, but, the equipments and this method of cooling are not yet in use in "Commercial size plants " in India.

Care must be exercised in ensuring that the cooled/frozen product is properly packed and maintained in a manner so that there is no fluctuation in temperature, until it is consumed.

Freeze Drying

Freeze drying process involves not only freezing of the product - of thin cross section - but also extraction of moisture by vacuum and/or controlled warming to achieve required dryness of product whereafter the product becomes shelf stable, if adequately and securely packed preferably under inert gas or vacuum. This technology is not in practice for 'Commercial size' plants in India.

Economic viability of this system could possibly be relevant only for 'High value' product or 'Emergency food operations' like war zones. This 'technology' is yet to be imported, though many important components of the system are within the competence of Indian industry.

Transport and Storage Refrigeration

Except 'Freeze dried' produce, all frozen/cold preserved products need effectively insulated cold chambers maintained at appropriate temperature by use of 'Refrigeration' system all through storage and transportation. We have all these systems available in India, including special insulation materials as well as mobile refrigeration units.

Thermal (Heat) Process Systems and Indian Manufacturing Competence

Types of heat exchangers for liquid/semi liquid products are given in Table 1.

These equipments for processing liquid foods into long life products, concentrates or powders - example - milk, whey, egg, tomato, malted foods, condensed milk, snack/sweet mixes (*Jamun, Vada, Idli*), jams and jellies, fruit pulps/concentrates/ juices, shrikhand, yoghurt etc., - Pouched in pouch, standy, irradiated bags, can retortable pouch, carton etc., Canning andpacking machines of form, fill, seal design are available in India. Depending on process and packaging adopted, shelf life of 2 to 12 months is achieved.

In these systems, one should be aware of the need for the other special components such as :

i) Homogenisers - manufactured in India

ii) Special 'Roto' pumps for viscous/concentrate products - manufactured in India

Except 'Freeze dried' produce, all frozen/cold preserved products need effectively insulated cold chambers maintained at appropriate temperature by use of 'Refrigeration' system all through storage and transportation.

Retortable packaging/canning processes for liquid products : In this category, if products are the examples of fruit pulps, juices, jams hot filled into tin coated cans or retort pouches - which further undergo 'in-pack' sterilisation in a retort kettle - at a particular temperature and pressure according to product and size of container - to ensure centre of the container achieving the sterilizing temperature. Desired hot filling is achieved by one of the types of heat exchangers mentioned earlier. So, the temperature is reduced to 45^{0}C. Cans/retorted pouches are cooled by natural/water bath. Multistage heating alters the natural flavour, taste, and quality considerably but offers shelf-life of more than 6 months. All equipments for this system are available in India.

Multistage heating alters the natural flavour, taste, and quality considerably but offers shelf-life of more than 6 months.

Extrusion Process

In this form of pressure/temperature combination of cooking cereal/pulses-based ready-to-eat breakfast/snack foods results in a very good quality product.The design offers hygienic, continuous and energy saver options. Due to high pressure/temperature conditions, system needs careful attention. Large scale producers still rely on imported systems (Wenger etc.), though small and medium scale - Indian made extruders are producing satisfactory extruded products, which provide many advantages in a variety of products that can be produced, level of dehydration/cooking achieved as well as shelf-life and economic packaging advantages. Defence units are sure to benefit by adopting this process more extensively and encouragement would be well placed.

Roasting / Frying Systems

These process systems have extensive use in snacks industry and India does have desired design and manufacturing infrastructure suitable for both - small scale and large scale units. Roasted nuts/pulses/cereals not only improve keeping quality but also simpler packaging parameters.

Automation in 'frying' systems is visible in hotel industry as well as Indian sweets industry - but only, when large scale production is involved. Example are *Rosagolla/Gulab Jamoon* produced by AMUL.

Another case for 'mechanized frying' is the case of

Table 1. Types of Heat Exchangers for Liquid and Semi-liquid Products

Types of Heat Exchangers	Remarks
Scrape Surface Heat Exchangers Vaccum assisted concurrent, counter current, falling film raising film tubular heat exchangers, scrape surface evaporators - concentrators	Engineering capability as well as extensive successfully installed operating projects for a variety of normal and
Scrape surface heat exchangers Vaccum assisted concurrent, counter current, falling film raising film tubular heat exchangers, scrape surface evaporators - concentrators	
Spray dryers and flash dryers Roller dryers Tray dryers Sterilising/retorting equipments	Special food products - both for batch and continuous operation - is within the competence of Indian food equipment manufacturers.
Continuous aseptic processing & packaging systems - involving scrape surface heat exchangers, Special 'Aseptic chamber' fillers and product metering auto controls.	In the past 10 years,a number of these commercial scale systems - of Italian & US origin - have been imported, installed and successfully operated for high acid products of fruit pulps & concentrates. These are automatic plants with computerised controls. The processed product is filled into pre-sterilised - by irradiation - multilayered, high vapour barrier, imported bags which in turn are protected by a CFB cartonor steel drums for safe transportation. Because of cold filling of product, quality is obviously better. Sophistication of this system design is very much in use in many large 'non food' chemical processes in our country executed by 'absorbed technology' manufacturers of repute. Areas needing 'Indian inputs' to meet food process standards are development of sanitary values, instrumentation, micro filters, PLC's - accurate, quick response, PLC controlled, pneumatic/hydraulic units - or import of these components. PCL controlled viscosity/flow meter is another critical component needing import. Important aspects of design in aseptic plants are hygienic (sanitary) Construction - Double mechanical shaft seals with or without steam shroud, CIP facility, probes and instruments have been developed in India.

large scale production of *Samosas* as also *puries* - highly possible. (Change of 'tetrahedron' shape of *samosa* to rectangular shape improves mechanisation)

Mechanized frying provides for uniform frying as well as enegy and oil consumption economics.

Hotel industry and large food caterers like defence and industry canteens should encourage Indian equipment producers instead of easy option of imports.

On the topic of frying systems, one area of extensive use is the potato chips industry, where continuous 'chips processing systems' are common practice as in West. Investment levels of imported systems result in cost of chips, which Indian citizens cannot afford.By selectively moderating mechanisation to peeling, slicing and frying only, a combination of safe manual and mechanised systems without sacrificing hygiene requirements as well as affordable price could probably be achieved - even in this case up to 5 tonnes chips production/day could be the economically viable production volume. In order to contain packaging costs and transit damage, cluster of units with minimum transportation is indicated and such smaller units do not offer economics of scale.

Basic objectives of maximum yield and minimum oil con-

Table 2. Indian Engineering Competence to Cold/Heat Cycle Preservation

System	Status of Indian Engineering Competence
Cold chain system	
Vapour compression systems & secondary coolants	100%
Deep freeze systems	100%
Liquid refrigerant system	- Refrigerants - moderate volumes - Controls - Imports equipments. - Design and engineering, 100%
Freeze Drying	- Design / technology - imported - Physical components - 100%
Transport refrigeration	100%
Thermal (Heat) systems	
Plate type heat exchangers Shell and tube heat exchangers Tube in tube in heat exchanger Scrape surface heat exchangers Vacuum assisted concurrent, counter current, falling film raising film tubular heat exchangers, Scrape surface evaporators - concentrators Spray dryers and flash dryers Roller dryers Tray dryers Sterilising / retorting equipments	100% except scrape surface concentrators & sterilizers
(a) Aseptic systems	100% Except - Aseptic fillers -PLC controls -Irradiated bags
(b) Homogenisers	Partly produced
(c) Roto pumps	100%
Canning retort pouch systems	100%
Form, fill, seal systems	100% (except aseptic variety)
Extrusion systems	100% Medium scale plants
Roasting / frying systems (including machines for *samosas*, chips, chicken etc.	100% Small scale - Partly mechanised - units (In use - Large scale units imported)
Continuous cooking systems	Indian competence exists
Irradiation systems	100% by BARC
Various food packaging	Almost 100% availability

sumption call for efficiency in peeling, in slicing, controlled temperature and satisfactory de-oiling coupled with sanitary design and SS construction. While competence in manufacturing such special equipment exists, economic 'volume production' can only result in viable costs.

Table 3. List of Illustrations

Product	Indian Engineering Competence
Tube in tube heat exchanger	Possible in future - Presently imported.
Scrape surface concentrator I -- Do --	Within Indian competence and operating in India
Filtermat dryer	Design and manufacture possible
Tray dryers	In production for many years
Aseptic process schematics Aseptic filler schematics Aseptic Filler	Competent - some components need import
Roto pumps	In production
Rotary fryer Continuous fryer	Design and manufacture possible
Continuous cooker	-- do --

Continuous Cooking System

Continuous cooking is another form of preserving food - mechanisation of which is within the competence of Indian engineering.

Nuclear Energy (Irradiation) Systems

BARC has developed batch and continuous irradiation system for various products. In India, it is the only institution offering this facility for food and medical production in different locations. There is no need to elaborate on acceptability, risks, investments, cost of preservation, statutory obligations etc., of irradiation systems. But, it is believed that this system has relevance to defence needs of preserved foods.

A summary of Indian engineering competence to cold/heat cycle preservation is presented in Table 2.

Hotel industry and large food caterers like defence and industry canteens should encourage Indian equipment producers instead of easy option of imports.

Indian competence in product availability with illustrations are given in Table 3.

The major constaints in the manufacture are sizes and number of machines to be produced per year. A few precision engineering process of honing of homogenisers and scrape surface heat exchanger cylinders, sanitary products, micro-values and servo- values - are economically prudent by import.

It is a well established commercial practice - what systems or components can be readily purchased from or sub-contracted to established manufacturers - need not be produced 'in-house'. This practice will change only when 'Volumes of numbers' to be produced in large and/or competitive technology advantages are available.

This practice continues with all 'organisations, who make 'one time' investment in improved technology, through imports, instead of calling on Indian manufacturers to 'one off' systems involving risks of performance, service and spares guarantees.

Poly-β-Hydroxybutyrate : Biodegradable Thermoplastic

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Introduction

Our environment is losing its integrity due to the indiscriminate use of plastics. Plastic remains constitute probably one of the worst problems associated with solid wastes of industrialized societies. Plastics are non-biodegradable and hence accumulate and persist in the terrestrial as well as in the aquatic environment for very long periods, causing ecological imbalance and aesthetic deterioration of the nature. When disposed into marine environment, they do not settle to the bottom. On the other hand, they float on the surface due to their low density. More than one million marine animals die every year by choking or entanglement with plastic debris (Bean, 1987). Production of synthetic plastics is energy intensive and are by-products of petroleum industries. Production and recycling of plastics produce a lot of hazardous toxic chemicals, which pollute our ecosystem. Probably, the best solution to the environmental problem created by plastic wastes is the use of biodegradable plastics, which degrade microbial enzymes leaving no residues or traces. This paper describes some microbial systems as potential candidates for the development of bioplastics and their possible applications in the context of environmental pollution.

Role of Polyhydroxy-Alkanoates

Among different bioplastics, polyhydroxyalkanoates (PHA), the bacterially produced bioplastics, can well become the best biodegradable substitute for synthetic polymers. Under unbalanced growth conditions (limitation of nutrients like phosphates, sulphates), some bacteria, for example, *Bacillus* sp., *Azotobacter* sp., *Clostridum* sp., *Thiothrix* sp. etc. shift from their original physiological pathways and synthesize carbon reserve compounds. The best known, although probably not the most common in nature, is poly ß-hydroxy butyrate (PHB). These are intracellular inclusions and biopolymers with repeating subunits and are chemically and osmotically inert. Because of their similar repeating structure with minor variation in the side chain, these are collectively called poly β-hydroxyalkanoates, (PHA) Chemically, they have the following structural formula :

Plastics are non-biodegradable and hence accumulate and persist in the terrestrial as well as in the aquatic environment for very long periods, causing ecological imbalance and aesthetic deterioration of the nature.

$$\{-O-\overset{R}{\overset{|}{CH}}-CH_2-\overset{O}{\overset{\|}{C}}-\}n$$

R=n-alkyl group of variable chain length

The value of n may vary from 600 to over 35,000.

These inclusions are membrane bound, but the enclosing membrane structure does not correspond to that of Singer and Nicolson's membrane model with a phospholipid bilayer as the basic structure (Jensen and Siko, 1971). The size of the individual granule varies from 100 to 800 nm in diameter. They are generally spherical in shape and found

enclosed in non-unit membrane (Ellar *et al.*, 1968). Poly β-hydroxy butyrate (PHB), exists in fibrilar form with a polymeric chain length of 10-15 nm. The fibrils are formed as a result of simultaneous synthesis and crystallization of water insoluble biopolymers. These biopolymers show a greater degree of crystallinity (80%). The monomeric units of PHB are polymerised inside a micelle consisting of the PHB synthetase yielding polymer fibrils.

Polyhydroxybutyrate is an aliphatic polyester with alternating carbonyl oxygen and methyl groups along with length of polymer chain. Biosynthesis of PHB and its degradation is well known (Dawes and Senior, 1973). It is formed by head to tall condensation of two acetyl-CoA molecules catalysed by β-ketothiolase. The four carbon intermediary acetoacetyl-CoA undergoes a reduction to β-hydroxy butyryl-CoA catalysed by an acetoacetyl-CoA reductase. Finally, the four carbon monomers are polymerized by the PHB synthetase and establish ester linkage between the acid group of one unit and the hydroxyl group of next and the polymer accumulates intracellularly.

PHB as Bioplastics

During the early sixties, the first patent proposing the use of PHB as a commercial plastic was filed (Baptist, 1959, 1960). However, it was not until much later that the potential was understood, when a polymer containing other monomer in addition to PHB was isolated (Wallen and Rohwedder, 1974). Now, it is becoming more clear that the homopolymers of PHB as an intracellular carbon reserve are the exception rather than the rule.

PHB has stability in UV light (Webb and Brown, 1986). An increase in spherulite diameter results in an increase of the toughness of PHB. This deformation of spherulites by "cold rolling", has a strong effect on the mechanical properties of PHB and greatly increases the ductility. The physical properties of PHB are induced by the molecular weight of the polymer, which depends upon the particular strain of bacteria used. PHB crystallizes slowly during cooling. The maximum speed of crystallization is found between 110 and 120^{0}C. In absolutely pure PHB, nucleating site is lacking, and hence crystallization slows down (Webb and Brown, 1986). It has been shown that PHB molecule in the crystalline state assumes the right handed double helix (Cornibert and Marchessault, 1972; Yokouchi *et al.*, 1973). PHB shows a wide range in its solubility and the solubility in organic solvents has been utilized to extract PHB from moist or dry microbial biomass on a pilot scale. Chloroform, pyridine, methyl chloride and ethanol mixture (Barham and Selwood, 1982), ethylene carbonate and propylene carbonate (Lafferty and Heinzle, 1977) are solvents commonly used for pilot scale extraction of PHB. The solubility of PHB is temperature dependent and also shows thermal degradation like other biological compounds (Grassie *et al.*, 1984). The properties of PHB vis-a-vis polypropylene are shown in Table 1.

Polyhydroxybutyrate is an aliphatic polyester with alternating carbonyl oxygen and methyl groups along with length of polymer chain.

Advantages of PHB

PHB offers certain distinct advantages over other conventional plastics as indicated below.

(i) Completely biodegradable; (ii) Biocompatible; (iii) Eco-friendly; (iv) No need for petrochemicals; (v) Hydrophobicity; (vi) Good thermoplastic, crystallizes slowly when cooled; (vii) Good flexibility; (viii) Excellent moldability; (ix) Resistant to heat disinfection; (x) Stable under visible and UV light; (xi) Good tensile strength and extension to break; (xii) Plezoelectric property and (xiii) High melting temperature.

Disadvantages of PHB

As such, the natural PHB has the following disadvantages as a commodity plastic.

a) Degree of crystallinity is too high giving the polymer very low elasticity and high brittleness; b) High melting point and severe thermodegradability above melting points make the polymer unsuitable for thermal processing.

However, co-polymers of hydroxy butyrate and hydroxy valerate show low crystallinity and low melting point. This shows a decrease in stiffness and an increase in toughness. Melting temperature is also drastically reduced making processing easier. Co-polymers of 3-hydroxybutyrate and 4-hydroxybutyrate possess even lower crystallinity producing extremely elastic polymer (Doi *et al.*, 1990).

Many different polyhydroxy alkanoates can be enzymatically formed by microorganisms from a series of precursors and is most probably due to the lack of specificity of the initial key enzyme b-ketothiolase. Polyhydroxy alkanoates with specific properties such as melting point, degree of crystallinity, tensile strength, gas permeability and impact strength can be achieved by controlling the growth conditions of the organisms (Senior, 1985). The changeover from the synthetic plastic to biodegradable materials,

Table 1. Properties of PHB and Polypropylene

Property	PHB	Polypropylene
Molecular weight (Daltons)	$(1\text{-}8) \times 10^5$	$(2.2\text{-}7) \times 10^5$
Melting point (^0C)	171-182	171-186
Crystallinity (%)	65-80	65-70
Density ($g.cm^{-3}$)	1.23-1.25	0.905-0.94
Tensile strength (MPa)	40	39
Extension at break (%)	6-8	400
Resistance to UV radiation	Good	Poor
Biodegradability	Completely biodegradable	Comparatively less
Oxygen permeability ($cm^3m^{-2}atm^{-1}d^{-1}$)	45	1700

will be long and expensive but alternatives are not suitable for long term usage (Fuller, 1990).

Production of Plastics from Bacteria

There are two different ways of achieving polymer formation by using microbes. First, conversion of growth substrate by metabolism to form both microbial biomass and storage of polymer simultaneously, which is commonly observed in *Rhodospirillum rubrum* and *Pseudomonas oleovorans.* During cell growth, part of the polymer forming potential is lost because of the utilization of the substrate to maintain the cell metabolism. The second possible method of industrial polymer production is a serial process, where microorganisms are first grown on a carbon source to obtain a large amount of biomass, then the medium is depleted of an essential nutrient and a polymer forming substrate is added. The latter is converted directly to polymers and essentially only little additional cell growth occurs. Generally, this approach is used for the large scale PHA production by *Alcaligenes eutrophus.*

A subsidiary of the British Corporation ICI is commercializing co-polymers of hydroxybutyrate (HB) and hydroxyvalerate (HV) under the trade name BIOPOL. They obtained the co-polymer from the soil bacterium, *Alcaligenes eutrophus,* using a medium with glucose as carbon and energy source and propionic acid as precursor for the HV monomers (Holmes *et al.*, 1981). The organism is cultivated in a feed batch to improve productivity followed by phosphorus limitation, which is the triggering stimulus for the polymer accumulation that reaches upto 80% of the cell dry weight with an overall yield of 0.3 g of polymer per g of carbon substrate (Byrom, 1987). BIOPOL can be processed to give a product typical of the plastic industry. It has the potential of providing the world with a biodegradable commodity plastic in the 21st century, which is produced from renewable resources (Uttley, 1985, 1986). In addition to PHB, other types of biodegradable plastics based on the addition of starch to the thermoplastic polymer are under production. Certain companies also started manufacturing biodegradable plastics (Evans and Sikdar, 1990). However, the present cost of the biodegradable plastic products are 25 - 30 times more than the cost of conventional polyethylene, which prevents a more extensive market potential (Pearce, 1990). Besides, with the conventional fermentation technology utilized, to increase the production of BIOPOL to supply a potential market of hundreds of thousands of tonnes per year would require a huge investment in the production plant.

Genetic Engineering for Bioplastic Production

One way to bypass the limitations and to improve the economics of PHB production would be the use of different organisms as PHA producers. In this regard, it is worth noting that the production of PHA by genetically manipulated strains of *Escherichia coli* has been described (Peoples and Sinskey, 1989). By introducing the three genes coding for three important enzymes involved in PHB synthesis i.e., beta-keto thiolase, acetoacetyl-CoA-reductase and the PHB synthetase, into *E.coli*, this organism has been reported to accumulate as much as 90% of cell dry weight as PHB (Slater *et al.*, 1988).

Though cloning and expression of PHB gene in *E. coli* was successful, many reports (Haigermoser *et al.*, 1993) indicate that,

there is a segregational instability of the plasmid vectors used for such purpose. Recombinant PHB encoding plasmids are rapidly lost from host cell so that plasmid free cells become dominant even under the conditions of selection for the plasmids. Scientists in the emerging field of biopolymer engineering are endeavouring to produce bacteria and eventually food crops that are genetically tailored to yield a whole new breed of plastics. It is already possible to grow vats of microbes, which can produce plastic. Eventually, it is hoped to modify the potato (*Solanum tuberosum*) so that the tuber produces polymer in place of starch. Such biopolymers could be cheaper than polymers made chemically from hydrocarbons (Pool, 1989). PHB could be produced in plants by expressing suitable bacterial enzymes in plant cell cytoplasm. Plastid has a high level of acetyl-CoA. Since it is the site of fatty acid biosynthesis, substantial diversion of acetyl-CoA from fatty acid biosynthesis towards PHB may be possible without affecting the plants (Nawrath *et al.*, 1993). Successful cloning and expression of PHB synthesizing genes in certain plants have been reported viz., *Arabidopsis thaliana* (Rhee *et al.*, 1992), *Brassica napus*, *Nicotiana tabacum* (Smith *et al.*, 1993), *Glycine max* (soybean), *Helianthus annus* (sunflower) (ICI Patent). However, these plants were impaired in growth and the yield of PHB was low, since the expensive reduced carbon source (glucose) necessary for optimal PHB accumulation in heterotropic organisms like *Alcaligenes eutrophus*, increases the production cost of biopolymer. Hence, attention is now being paid to autotrophic cyanobacterium like *Spirulina* sp. (Heinhorst *et al.*, 1991) and algae like *Rhodospirillum rubrum*, which require little more than water and sunlight for growth and plastic biosynthesis. The plastic genes can be altered to create new products i.e., synthetic rubbers and unusual types of plastics.

Fermentation Process for Large Scale Production

Many microorganisms have been experimented to get PHB by fermentative process. The fermentation substrate, energy (carbon) sources and the limiting factors are as diverse as the organisms used in many experiments. Any carbon source can be used for fermentation but it depends upon the requirement of selected strains. Commonly used carbon sources are glucose, fructose, malate, acetate, pyruvate, methanol, methane, butane, lactate etc.

One way to bypass the limitations and to improve the economics of PHB production would be the use of different organisms as PHA producers.

Similarly, many limiting compounds have been experimented viz., ammonia, carbon, iron, magnesium, manganese, oxygen, phosphate, potassium, sulphate etc. The organisms of commercial interest are *Alcaligenes eutrophus*, *Alcaligenes latus* and *Pseudomonas oleovorans*. Other than these, a variety of organisms like *Azospirillum, Azotobacter, Beggiatoa, Leptothrix, Methylobacterium, Methylocystis, Rhizobium, Rhodospirillum, Sphaerotilus, Spirillum* etc., are well known to accumulate PHB intracellularly in a natural environment.

Like any other fermentation process, environmental factors like salt concentration, nutrients, light, pH, O_2 etc. do affect the PHB yield, but in large scale production systems, optimum conditions are required and maintained throughout the fermentation process to hasten PHB yield.

Extremophiles as PHA Producers

Presently, extremophiles like halophilic organisms are attracting attention of research workers, as they can be exploited for PHB production where they exclude the growth of most or all contaminants. *Haloferax mediterranel* (Garcia Lillo and Rodriguez-valera, 1990) is one of the halophilic archaebacteria, characterized by very high NaCl requirements in their environment (Grant and Larsen, 1989). These are aerobic, chemoorganotrophs and grow commonly in salt precipitation ponds giving them their typical red hue. It has been reported that *Haloferax mediterranel* R_4 accumulates 67% PHA (% on dry weight basis), when grown on starch substrate (Rodriguez-valera, 1991).

Extraction of PHB

PHB can be extracted either by treatment with organic solvents or by complete cell lysis using enzymes (Harrison *et al.*, 1991). Generally, PHB granules are extracted from fermentation broth by treating it with solvents having boiling point less than 100^0C in presence of water and allowing it to settle by centrifugation. Then, the organic phase is separated from aqueous phase containing undissolved cellular debris and sprayed into water at a temperature above the boiling point of solvent. When the solvent evaporates, PHB precipitates in water, which can be further separated and purified by simple techniques.

Biodegradation of PHB

The faster growing component in municipal solid waste is plastic. Although, the major polymers are non-biodegradable, recent legislations have mediated

the use of biodegradable plastics in USA. In this respect, PHB, PHV and other co-polymers are 100% biodegradable (Krupp and Jewell, 1992). BIOPOL takes around six weeks to get completely degraded by soil fungi (Matavuiji and Molitoris, 1992). PHA's are sensitive to lipases of microbial origin. Hence, they get degraded quickly in soil and sanitary land fills (Mukal *et al.*, 1993). The most common microbes responsible for PHB degradation are *Acidovorax facilis, Variovorax paradoxus, Bacillus sp., Streptomyces sp.*, moulds like *Aspergillus fumigatus, Penicillium sp.*, etc. (Mergaert *et al.*, 1993). PHBs/PHVs are degradable in all natural environments and their co-polymers are degraded faster. Degradation of PHA in freshwater ecosystem is slow, whereas in sea-water, degradation occurs rapidly. In soil, with increase in temperature, degradation of PHB becomes faster, especially with co-polymers and the degradation rate increases with increased PHV content in the polymer (Mergaert *et al.*, 1992). In natural environment of sanitary landfill, compost and sewage sludge, wild strains of myxobacterium play an important role in biodegradation of poly beta hydroxy alkanoates, as most of the myxobacterial species have PHA-depolymerase activity (Gilmore *et al.*, 1991.)

Applications of PHB as a bioplastic

The potential applications of bioplastics in different areas are described below.

Medicinal use

As biopolymers (PHB) are biocompatible and non-toxic, these are preferred for manufacture of biomedical materials like sutures, surgical pins, staplers and swabs. This can be used for wound dressing, blood vessel replacements, artificial skin material, bone replacements and reconstructive surgery. Further, they are also preferred as biodegradable carriers for long term dosage of drugs and used for slow release applications in pharmaceuticals and food industry. Since PHBs possess piezoelectric properties, it can be used as a stimulant for bone growth and quick setting of bone fractures. This can be used for preparation of disposable items such as diapers, sanitary articles or feminine hygiene products. These co-polymers are biodegradable, biocompatible and at the same time not thermally decomposed. They are resistant to heat and thermal disinfection and have excellent moldability and sufficient thermal stability to allow heat sterilization. All these properties make it suitable to be used in medicine and surgery (Brandi *et al.*, 1990).

As biopolymers (PHB) are biocompatible and non-toxic, these are preferred for manufacture of biomedical materials like sutures, surgical pins, staples and swabs.

Agriculture

Biodegradable plastics are in use for mulching of maize (Le-Du and Wierzbiski, 1985). Biopolymers can be used as small spheres for slow release of herbicides, insectides, fungicides or fertilizers. It can be used for slow release of marine anti-fouling agents (Mantovani and Vaccari, 1991). Biopolymers also have horticultural applications such as mulch films, moss stick etc., Fishing nets and fishery materials can also be produced from these polymers. Biopolymers can be used for preparation of polypacks or pots for saplings, which can be transplanted directly to soil and subsequently degrade making the plant free in soil. PHB polymers may also be applied for microelectronics.

Food Industry

Biopolymers can be used for preparation of biodegradable packaging containers, bottles, wrappings, bags and films. Biodegradable plastics drinking straw filled with cold processed honey (Honeystrix) are already in market in European countries (Dunham, 1988). Water repellent film forming composition can be produced by mixing PHBs with halogen solvent. This can be used for surface treatment of paper, wood products and fibre products which will be useful for food packaging. PHBs can be used as a gas barrier film. PHBs have adhesive, water repellency and mechanical strength as well as compatibility. These properties make PHB as a suitable food packaging material. Strong recommendation has been given by German Federal Office of Public Health concerning plastics intended to come in contact with food (Evers, 1991).

Furthermore, PHB can be processed by traditional techniques used in the plastic industry such as injection molding, extrusion, blow molding, melt casting or spinning. PHBs have the potential to become an important source material for commodity plastics which are biodegradable (Mann and Calvert, 1987). The acceptance of such materials is expected to be very gradual and it has been predicted that in the year 2002, only 3% of the estimated annual 15 million tonnes of plastic-packaging waste will be degradable (Leaversuch, 1988).

Biodegradable plastics currently available can only be used for certain specific applications, such as in high temperature and impact resistant plastics cannot be replaced at this time and there are other problems related to use of

biodegradable materials. A prolonged contact with biodegradable plastics used as packaging materials could conceivably cause the contamination of food by undesirable microbes which could grow on the plastic. The uncontrolled disposal of some biodegradable plastic items could also cause the eutrophication of certain aquatic ecosystems (Brand *et al.*, 1990), because the material would serve as easily mineralizable organic matter.

Conclusion

Bacterial PHB's are an original and diverse set of biological polymers that furnish a new tool for material science in several applications that often, but not necessarily always, will take advantage of their biodegradability. Their impact on the global polymer market will depend considerably on the capability of biotechnologists to reduce production cost. Genetic manipulation and use of novel and better producing organisms represent two ways to achieve this aim.

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Continued on page 45

NEW MACHINERY

Rice Bran Separation System

Rice bran separation equipments pneumatic bran separation system is the latest in the range of Modern Rice Bran Milling Machinery manufactured in India. The system not only separates rice germs and brokens from bran, but also conveys the bran pneumatically, thus obviating the need for separately sacking the bran at each polisher.

The bran separator consists of a powerful centrifugal fan which aspirates the bran from the polishers and delivers it to cyclone. An auxiliary cyclone and blower aspirate the bran from the outlet of the main cyclone and thus fine bran is separated from coarse contaminants.

The system works without any sieves and their associated moving parts. Consequently operational and maintenance costs are the lowest. (Rice India, March '97)

Rice Bran Stabiliser

This is a continuous processor, employing a duplex system jacketted cum conveyor, whereby the fresh bran produced in the modern rice mills can be effectively treated. The bran stabilised by indirect heating to a temperature of 90^0 C - 100^0 C can be safely stored for about 2 to 3 weeks with a free fatty acid content not exceeding 5 per cent. Hence the oil extracted from such bran is suitable for edible purposes. The cost of stabilisation is less than 30 per cent of the extra price the stabilised bran fetches in the market.

The continuous stabiliser is a sturdily built machine requiring little or no maintenance. A positive drive consisting of a TEFE motor and gear box unit with a strong chain drive ensures sustained trouble-free operation for long periods. It's wide capacity range makes it most suitable for rice mills of 2 to 4 tonnes per hour capacity.

Rice bran can also be stabilised by extrusion process for which there is technology available in India and few manufacturers are engaged in manufacturing these equipments. (Rcie India, March '97)

ASTRA Drier

Technology Demonstration Centre, Sirsi in collaboration with the ASTRA (Application of Science and Technology for Rural Areas) department of the Indian Institute of Science, Bangalore has designed a cardamom drier of 25 kg, 50 kg, 75 kg and 100 kg capacities. This system has been tried by a number of growers in Karnataka, Kerala and in ICRI, Myladumpara and found it cost and fuel-efficient, compared to the conventional system. The performance of the dried produce is found satisfactory.

ASTRA drier is also used for drying other agriculture produces like arecanut, coconut, ginger, turmeric, pepper etc. Cost of fabrication and installation of one 50 kg capacity drier is about Rs. 30,000/-. More details of the drier could be obtained from Technology Demonstration Centre, Yadahally, Sirsi, Karnataka.

New Cost-Saving Stretch-Wrapping Film Cling

Three -layer film manufactured by a new Irish plant gives noise reduction, cost reduction and greater stretch with maximum load- holding capability.

A new type of resin for creating the surface 'cling' characteristics of stretch-wrapping film used in high-speed pallet-and bundle-wrapping machines, had led to a noise reduction of 20-30% compared with most other films currently available.

Like other ITW Mima stretch films being manufactured at the new Waterford plant, *Accu Wrap Star QT* is produced from three separate layers, each formed by the blown-extrusion process, which are brought together in their molten state and passed through a circular die to form a tough, unified film.

The 'cling' characteristic can be limited to the side of the film in contact with the load, providing strong holding power, while the outer layer is formulated to provide a slippery, abrasion- resistant surface, thereby reducing the risk of damage during transit. Where the loads are to be stored for long periods in the open air, the outer layer can also incorporate an ultra violet inhibitor, or be rendered opaque to conceal the contents of the package. The inner layer of film is formulated to provide the best possible combination of strength and stretchability.

ITW Mima produce a series of films with stretching capabilities ranging up to 300%. With a stretch

rate of 300%, each metre of film on the roll can stretch to 4 m, when wrapped around the load. By such means, savings in film costs can be as high as 60%.

Cost savings are also generated through the blown-extrusion process, which allows the manufacture of film up to 20% thinner than that achieved by the cast process. This combination of thinner film offering greater stretch capabilities improves considerably the output per roll, reducing significantly wrapping costs. Where pallets or other loads are to be wrapped by hand, even the strongest personnel are rarely able to stretch a film by more than 30%, with the risk that the load could shift and become damaged because the wrapping is not tight enough. ITW Mima overcome this problem by supplying pre-stretched film, such as *Strength Wrap*, for hand-wrapping applications requiring less effort by the operative, while ensuring maximum package security and reduced material cost.

For further information contact :

ITW Mima

Belview Port

Waterford

Ireland

Tel : +353 51 851551 Fax : +353 51 851630

Multipurpose Mill

Vamp Engineers have introduced a Multi-Purpose Mill for carrying out operations like pulverization, granulation, shredding, etc. It consists of a vertically mounted 3-HP motor coupled to a shaft supported in a single piece cast bearing housing through a 3-V- groove pulley. The bearing housing is sealed with metal clad leather oil seal. The shaft rotates at 1,000/1,500/2,300 RPM depending on the process. Specially designed milling tool is fitted to the shaft and consists of two scrappers and twelve hammers. These are with knife/impact edges and can be used on any edge by reversal of hammers. Screen is supported around the milling tool by a quick opening device. The product to be processed is fed through a product feed hopper and can be regulated by a flap valve. The screen is covered with a quick opening guard. The equipment is mounted on a sturdy steel base fitted with castor wheels for portability. Various types and sizes of milling tools and screens are available to suit specific applications. The unit is provided with an electrical control panel. It is self-contained and portable. A dual speed motor can be provided to achieve six operational speeds as optional. The unit is available in GMP (paint-free) construction.

For further information write to :

Vamp Engineers Pvt Ltd

203 Rajguru Apartments, New Nagardas Road

Andheri (E), Mumbai - 400 069.

Kettle That Boils Before Your Eyes

Pifco, the British electrical group, has launched the electric kettle of the future using a technology that nearly halves the time it takes to boil water.

The energy-saving Russell Hobbs kettle, which the company claims to be the most advanced kettle in the world, is a boon to conservation campaigners and millions of tea and coffee drinkers. The performance is likely to push the adage that "a watched kettle never boils" permanently into oblivion.

The kettle uses a stainless steel disc that delivers heat directly into the water, unlike the traditional metal element that has to heat itself first.

The poweful three-kilowatt element helps to save time and energy with its improved efficiency and its ability to control the power. Moreover, its element resists limescale that afflicts many domestic appliances.

The new product has also enhanced the reputation of the company as an innovator at the cutting edge of today's technology.

For details write to :

Pifco Ltd,

Failsworth, Manchester,

United Kingdom,

M35 OHS.

Tel : +44 161 681 8321.

Fax : +44 161 682 1708.

Food Machinery from Top British Manufacturers

The British company BWI Dawson offers a complete range of filling, cleaning, handling and conveying systems to a worldwide customer-base. It has been particularly successful in dealing with the problem of side-wall flex as lightweight plastic containers are filled.

Dawson employs induction flowmeters to measure the passage of liquid into the containers to ensure a consistent volume of product is filled, and its new machine is capable of accuracy to within plus/minus 0.1%.

Another member of the BWI Group, BWI Fords, specialises in preformed-cup filling and sealing machinery which is used extensively in the food and dairy industries worldwide.

The product range available from the company, which is represented in Japan by Siber Kikai KK of Yokohoma, includes the Rockwell end of line tray/case erectors, case packers, wraparound machines and also shrink and stretch wrapping machinery.

Endoline Machinery Ltd is another British manufacturer strong in overseas markets with its wide range of end of line machinery from a semi-automatic sealer to a fully automated packaging line.

When it comes to labelling the finished products, Harland Machine Systems is a dedicated British company with a worldwide reputation. Harland designs, manufacturers and supplies prestige pressure-sensitive labelling systems, shrink sleeve systems and print/apply systems for product identification, decoration, promotion and security.

For details write to :

BWI Dawson, Gomersal, Cleckheaton, West Yorkshire, United Kingdom, BD19 4LQ. Tel : +44 1274 873422. Fax : +44 1274 824930.

BWI Fords Packaging Systems, Ronald Close, Woburn Road Industrial Estate, Kempston, Bedfordshire, United Kingdom, MK42 7SH. Tel : +44 1234 852365. Fax : +44 1234 853040.

Endoline Machinery Ltd, Stratton Business Park, London Road, Biggleswade, Bedfordshire, United Kingdom, SG18 9QB. Tel : +44 1767 316422. Fax : +44 1767 318033.

Harland Machine Systems Ltd, Hedgehog House, 2 Michigan Avenue, Broadway, Salford, Greater Manchester, United Kingdom, M5 2GY. Tel : +44 161 848 0622. Fax : +44 161 872 1547.

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To Our Readers / Subscribers

It is a matter of great concern for the new editor-in-chief and his team of editors that the issues are backlogged and the Editorial Board is taking strenuous efforts to bring the issues up-to-date. It is requested that the readers/subscribers may kindly bear with the inconvenience caused to them till things are set right. As a first step, Nos. 1&2 of Vol. 16 will be combined and published as one issue.

Editors

RESEARCH ROUND-UP

ECO-Friendly Oil from Plants

Experimenting with genetically engineered plants, researchers at the Scottish crop research institute have obtained natural oils suitable for a wide range of industrial usages ranging from plastic, plant and inks to cosmetics and pharmaceuticals.

As part of a project examining alternative oil sources to replace the diminishing supply of pollutant fossil fuels, scientists discovered that meadowfoam plant produced natural oils, which could be invaluable in manufacturing processes.

Meadowfoam oil remains steady under high temperatures and would be a suitable lubricant for satellite operations, as it does not break down in outer space. Space research technicians have hitherto relied on oil from sperm whales, but a worldwide ban on the product has opened the door for alternatives.

Dr. Steve Millan, a crop scientist at the institute is working on a number of plants to produce an environmentally friendly product. Oils are naturally produced there, unlike refined oil which is one of a number of species with the potential to replace fossil fuels.

Originally from Oregon in the United States where it is grown commercially, meadowfoam has only been genetically cultivated at the institute although there are crops in East Anglia. It is closely related to a common garden weed called poached egg plant. With a little biotechnology and genetic engineering, the institute hopes to improve the plant commercial production.

Australian Rice - A Genetic Engineering Feat

Australian Research Scientists have developed highly efficient system of genetic transformation, which is being used to introduce cold tolerance and other grain quality genes into Australian variety 'Jarrah'. One of the major problems being faced by rice scientists around the world is the inability of most of the popular varieties of crop to tolerate low temperature. Efforts by plant breeders to improve cold tolerance in rice varieties by conventional cross-breeding methods using genes of various rice varieties grown in different countries did not produce satisfactory results. Thanks to advancement in biotechnology, which has now enabled scientists to transfer properties such as cold tolerance from plants or unrelated species to rice. The wild rice of North America *(Zinzania Palustris)* is an acquatic grass and is well adapted to the low temperatures. *Zizania* cannot be crossed with commercial rice by conventional methods, preventing the introduction of the cold tolerance property of *Zizania* into commercial rice varieties. However, Zizania also have grain flavours and textures that would be marketable if introduced into rice. Australian scientists therefore, worked on to isolate certain genes from Zizania and introduced them into rice variety 'Jarrah' using state-of-the-art biotechnology techniques.

Genetically Engineered Oral Cholera Vaccine Strain

The Indian Institute of Chemical Biology (IICB), Calcutta, has developed a genetically engineered potential oral cholera vaccine strain.

For producing the strain, naturally occurring isolate of *V. cholerae* 01 EI Tor, which did not possess any of the enterotoxin genes responsible for diarrhoea, was selected, and from a series of *in vivo* and *in vitro* experiments, it was made certain that none of the toxin genes are present in the strain. The cholera toxing gene was cloned in a plasmid and engineered in such a way that the immunogenic, but non-toxic B subunit of the cholera toxin gene was retained intact and the toxigenic A subunit of the toxin was deleted. The plasmid carrying the attenuated cholera toxin gene was introduced into the non-toxinogenic clinical isolate. This recombinant vaccine strain was designated URD_2. It secreted the B subunit of the cholera toxin and the secreted protein inhibited the effect of cholera toxin secreted from a hypertoxinogenic *V. cholerae* strain in the rabbit ileal loop. The plasmid was found to be highly stable under both *in vivo* and *in vitro* conditions. URD_2 colonized the rabbit intestine and was devoid of att RS1 sequences, which have been shown to be involved in integration of the cholera toxin genetic element. Thus, for URD_2, it is not possible to gain the virulence cassette from the environment.

Toxicity tests of this strain have been carried out by the Frederic Institute of Plant Protection and Toxicology, Madras. The strain has been found to cause no undue toxicity and has shown a high efficacy in challenge experiments. Human trails are under consideration. It is expected that the side-effects associated with initial immunization by this strain will be minimal.

Further details can be had from :
Director, Indian Institute of
Chemical Biology,
Calcutta - 700 032.

Agrotechnology of Kiwi Fruit Plant

The Regional Research L-Aboratory, (RRL), Jammu, has been successful in introducing and growing the Kiwi Fruit plant in the J&K valley. The plant is indigenous to South-east Asia.

The Kiwi fruit *(Actinidia chinensis)* Launch, a member of family Actinidiaceae was introduced for the first time for cultivation trials in RRL (Branch) Srinagar, in 1984-85. After early set-backs and repeated agro-technical manipulations, the plant came to bearing in 1995, indicating the possibility of its commercial farming in the valley. In the first year, plant produces about 15-20 kg of fruit, which increases to more than 100 kg with the increase in the age of the plant. The harvesting is done in November and after picking, the fruit has to be rubbed with coarse cloth to remove surface hair. Fruit can be easily transported in hard condition and ripens following climatic change.

The fruit has a refreshing delicate flavour. It can be eaten as such or in combination with other fruits in salad and desserts. It is very rich in vitamin C content.

On The Trail of The Fish

It is reported that submarine signals lead whales to the shore instead of to their habitat in the depths of the ocean and by the time they discovered their mistake, it was too late for them to return to the safety of the waters.

It is yet another illustration of how sea-faring humans could play havoc with the denizens of the deep. There are also recurring reports of the depletion of marine fish stock as a result of excessive denudation by trawlers from depths familiar to them and beyond which they do not venture. Among the ways of inducing fishermen-venturing out to sea on catamarans or trawlers-is that of familiarizing them with unexplored areas where fish availability is large enough and which could be utilized for well-planned fish breeding. This is what the fish-finder designed and developed by the Electronic Research and Development Centre (ER & DC) of Thiruvananthapuram could do. The technology which it has developed by linking it to the Global Positioning System, is utilized for navigation purposes for locating large fish presence. The ER & DC's project was funded by the Department of Ocean Development and it will be able to supply fishermen with 100 fishfinders soon. The technology developed by the ER & DC has since been transferred to Bharat Electronics Ltd. and the Aero Systems Pvt. Ltd., in Bangalore.

New Method to Detect Milk Adulteration

Scientists at the National Chemical Laboratories (NCL), Pune have developed a technique to detect synthetic milk or milk adulterated with synthetics such as urea or detergent. A team of scientists at NCL, headed by Dr. S.S. Kulkarni and Dr. A.M. Bodhe, have succeeded in identifying reagents that can detect synthetic substances in milk. At a recent demonstration, the adulteration detection kit was well received by representatives from the dairy industry. The kit essentially consists of two chemicals and a standard colour chart. To detect adulteration, the consumer has to add a pinch of each of the chemicals to the milk, wait for five minutes and then compare the colour change in the milk, with that of the colour chart.

Target users for the kit would primarily be the dairy industry who can use it to detect adulteration by suppliers before it gets into the food chain. The kits can also be used by individual households to ensure the safety of the milk they consume.

The scientists are now contemplating plans to commercialize the kits. Mumbai- based Amrut Industries, one of the leading dairies in the metropolis, has reportedly evinced interest in the kit, both for its own use and for marketing it. The NCL team is, meanwhile, modifying the kit so that it is within the reach of individual households. They are confident that the modified kit will be ready in a couple of months.

Cracking Chinese Water Chestnut

The texture of edible fruits and vegetables is strongly influenced by the chemistry and physical properties of the plant cell walls. These structures, which are a major component of dietary fibre, make up the skeletal element of the plant. They surround every plant

cell, and wall-to-wall adhesion of adjacent cells provides mechanical strength and protection.

When we eat fruits or vegetables, their texture is determined, primarily, by the way the cell walls break and the tissue fractures. In uncooked vegetables or unripe fruits, tissue fracture involves rupture across the cell walls.

But in over-cooked vegetables or over-ripe mealy fruits, rupture of the very soft tissues involves cell separation. The cooking- or ripening-induced softening actually results from solubilisation of the pectic polysaccharides that "glue" adjacent cells together. Of course, some tissues are intermediate between the crunchy and soft extremes.

Chinese water chestnut (CWC) is an unusual vegetable that is much prized in oriental food. This corm of an aquatic sedge consists of starch-rich, thin-walled cells, very similar to those of potato. But in contrast to potato, CWC retains a firm and crunchy texture after extensive cooking or canning.

This is because heating fails to induce cell separation. There have been several unsuccessful attempts worldwide to relate this unusual property to the underlying chemistry of the cell walls. A process, has been developed at the Institute of Food Research (IRF), in UK to chemically extract fresh or cooked CWC tissues. This solubilises cell-wall components sequentially. It was noticed that after treatment in dilute alkali, CWC tissue turned a bright yellow. Microscopic investigations revealed that the cell walls fluoresced an intense green under ultraviolet light.

This suggested that the tissues contained esterified simple phenolics, probably ferulic acid (which is related to vanilla). By treating fresh or cooked CWC tissues with increasing strengths of alkali, the ferulic acid was extracted from the cell walls, and at the same time the cells could be separated.

This and other evidence strongly indicated that ferulic-acid components play a key role in maintaining crispness during cooking, possibly by forming heat-stable cross-links between polysaccharides that are themselves heat-stable.

Recently, new dimers of ferulic acid able to form such cross-links have been discovered in grass stems.

The ferulic acid dimers from grass had been identified by gas-chromatography together with mass spectrometry (GC-MS) and comparison with pure standards. This is a relatively expensive method for measuring such compounds and involves complex chemical procedures. Other methods of analysis such as high-performance liquid chromatography (HPLC) in conjunction with ultraviolet detectors are easier and highly sensitive, but even then precise identification would still require mass spectroscopy (HPLC-MS) and pure standards.

Using recent advances in HPLC technology, which allow the entire absorbance spectrum of the separated components to be monitored as they leave the chromatography column, phenolic acids and their dimers could be identified and quantified. This technique is so versatile that virtually all soluble phenolic compounds can be analysed in this way.

Conventional strategies for preventing over-softening during ripening of fruits and cooking of vegetables are directed at reducing cell separation by minimising the depolymerisation and/or solubilisation of the pectic polysaccharides, either chemically or enzymically.

It has been demonstrated that relatively small amounts of "simple" phenolics in cell walls of edible tissues can have a marked influence on the heat-stability of cell-cell adhesion.

The (bio)chemistry of such phenolics and their role in cross-linking cell-wall polymers may provide a new route for the control of texture in many plant-based foods. Investigations into the way in which ferulic acid becomes attached to cell-wall polysaccharides and facilitates cross-linking are already being initiated along with studies into the cell-wall enzymes responsible for dimer formation.

This is already attracting interest from several sectors of the food industry. The Institute of Food Research has a longstanding interest in plant cell walls in relation to food quality, diet and health. In addition, there are other areas which include nutritional aspects such as dietary fibre and the use of cell- wall-degrading enzymes in polymer modification.

RAW MATERIALS

Alfalfa

Alfalfa meal or lucerne meal is a feed ingredient for livestock and poultry. It has been approved by many international organizations, which have identified 29 types of meals based on their quality.

Besides 17 per cent protein, it is rich in calcium, potassium, trace minerals, vitamins and caroteniod pigment, a precursor of vitamin A. Lucerne meal contains 40 times more carotenoid pigments compared to maize. This is a responsible for its yellow yolk and skin colour. Hence, inclusion of one per cent of alfalfa meal in poultry feed will be equivalent to the inclusion of 40 per cent maize.

Moreover, compared to lucerne, meal contains 40 times as much vitamin A, two times more protein, six times more vitamin E, 10 times vitamin K and B_2, four times biotin, 50 times calcium, eight times manganese, two times methionine and zinc and three times more lysine. It also contains several growth factors, fertility factors and immunogenic factors, which no other single feed ingredient contains. It also have medicinal properties.

Due to presence of the various nutrients, feed manufacturers in several countries use alfalfa in all feeds at 2-3 per cent level, to improve feed quality, egg production, milk production, egg quality, fertility and hatchability. It prevents blood and meat spots in eggs. Such eggs are preferred by bakers and egg powder manufacturers. The meal imparts a very rich yellow colour to the skin of broiler, which is liked by fast food manufacturers.

The antioxidants present in alfalfa prevent oxidation of body fat, yolk fat and fat soluble vitamins and thereby enhance the shelf-life of eggs and meat. Alfalfa meal has been proven to increase the number of healthy chicks produced per hen.

Rice Husk

Rice husk has been one of the best raw materials and successfully used in developing a technology to manufacture particle board by the Indian Plywood Research Institute, Bangalore. This board has emerged as a versatile substitute for wood in wide range of applications. It can also be made decorative and elegant by incorporating suitable colours to look attractive. The technology utilises the most abundantly available agricultural waste - the rice husk. The board developed has certain distinct advantages (i) it is termite-resistance (ii) high decay resistant (iii) has improved fire resistance (iv) has excellent mechanical properties like internal board strength, elasticity, dimensional stability, screw and nail holding capacity etc. (v) has improved water resistance and (vi) highly durable.

The process involves clearing of raw materials application of ahering mat-foaming, edged trimming, sanding and stacking.

Cinnamon

Among the tree spices, Cinnamon (*Cinnamomum verum*) is an important drought tolerant, hardy crop ideally suited to dry hilly tracts. The cultivation of the cinnamon is concentrated in Shevroys, Kolli hills, Kallar Burliar, Courtallam hills and also in Kanyakumari district in Tamil Nadu. The existing plantations had been established through seedling progenies and productivity is not uniform. Further, the progenies derived from the seeds behave differently from each other because of segregation. Keeping this in mind, research programmes on tree spices were initiated as early as 1990 at Horticultural Research Station, Yercaud. Based on the research findings a high yielding cinnamon variety was identified during 1996, and released as YCD-I, cinnamon. YCD-I cinnamon is a selection from the germplasm, of open pollinated seedlings. It is suitable for cultivation in the hill ranges of Tamil Nadu at an altitude range of 500-1000 metres above M.S.L. This variety can come up in a wide range of soil. It grows well in loamy and laterite soils. It can be grown in areas receiving the annual rainfall of 1000 to 2000 mm and suitable for rainfed cultivation. Harvesting of bark commences from the third year, and can be maintained economically for 20 years.

This variety has the yield potential of 360 kg dry bark yield/ha with the regeneration capacity of 19.2 harvestable shoots in a year. The bark recovery is 35.3 per cent compared to the local type 22.4 per cent. The quills contain 2.8 per cent volatile oil whereas the leaves volatile oil whereas the leaves contain 3.0 per cent oil. The bark is light brown in colour with an attractive flavour. The bark is sweet and pungent. This variety has been accepted by farmers of Tamil Nadu because of its hardy nature, pungency, sweetness and high oil recovery. Both leaves and bark can be used. The leaves can be used in the curry masala preparations because of its high oil percentage. The variety is now being clonally propagated through cuttings, and distributed to planters.

Source : Spice India

CFTRI HIGHLIGHTS

Extruded Shrimp Feed

Shrimp culture is fast growing and there are plans to further promote aquaculture in India. There is a demand for a well formulated and nutritionally balanced feed which is a key input in semi-intensive and intensive aquaculture practices. Taking into account the nutritional requirements of shrimp (eg. *Penaeus monodon* species) with respect to protein, lipids, essential nutrients, the feed was formulated with the emphasis on development of process know-how for the production of nutritionally improved feed and optimisation of processing conditions such as time-temperature schedules of extrusion, role of binders to improve the hydrostability and pellet quality.

The process : The process, in brief, involves selection of appropriate raw materials, quality testing, disintegration of ingredients to optimum particle size, formulation, mixing, conditioning, extrusion, drying, packaging. Process is based on least - cost formulation using locally available ingredients.

Plant and equipment : The major equipments are disintegrator pulveriser, mixer, extruder and drier. The equipments can be fabricated in India.

The product : The pellets obtained are compact and hydrostable with low leaching loss. Pellets are free from potential pathogens like *E. Coli* and Salmonella. The pellets can be packed in polyethylene woven bags and stored at ambient temperature.

Utilisation : The pellets of 3-4 mm dia and 10-15 mm length can be directly broad-casted into ponds for grower shrimp.

For process know-how, terms and conditions please contact :

The Director, CFTRI, Mysore - 570 013.

Announcement

The Indian National Science Academy invites applications from scientists for partial financial assistance to participate in important scientific international conferences abroad during the year 1997-98. Scientists interested to avail of financial support from the Academy for participation in international conferences to be held during the year 1997-98 are requested to apply in the prescribed proforma, available from the office of the Executive Secretary, Indian National Science Academy, Bahadur Shah Zafar Marg, New Delhi - 110 002.

DATA BANK

India's Export of Non-Basmati Rice from Kandla Fort (April - Jan. 1996-97)

Country	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Total	% Share
S. Arabia	7634	6950	5712	3916	9402	1071	0	34569	35684	27341	132279	18.225
Russia	7816	0	12265	840	18293	1215	7615	14704	46997	8432	118177	16.282
Kenya	26590	27523	0	20421	0	0	0	40	0	3867	78441	10.807
Iran	29280	10549	14318	0	0	0	0	0	1296	703	56146	7.736
Senegal	0	0	9434	14587	12933	13653	2127	0	0	0	52734	7.265
Sri Lanka	0	0	0	0	0	0	0	0	15632	23358	38990	5.372
Australia	0	0	0	0	0	0	0	13126	0	14706	27832	3.835
U.A.E.	3981	874	724	2398	916	1748	4175	7285	3279	2283	27663	3.811
Syria	12120	0	0	0	0	0	0	12230	0	0	24350	3.355
Mauritius	0	0	0	0	0	0	12613	0	0	11365	23970	3.304
Somalia	0	0	9752	0	0	0	4640	0	0	3011	17403	2.398
Romania	2220	0	0	0	0	0	0	9929	0	0	12149	1.674
Philippines	10094	0	0	0	0	0	63	0	85	0	10242	1.411
Bangla Desh	0	7496	0	0	0	0	0	0	0	0	7496	1.033
Tanzania	0	0	0	0	0	0	6906	0	0	0	6906	0.951
Kuwait	381	168	375	572	654	473	1350	597	1534	450	6554	0.903
Nigeria	0	0	0	0	0	0	0	0	0	6531	6531	0.900
Ethopia	0	0	0	0	0	0	0	0	6020	0	6020	0.829
S. Africa	0	0	0	0	0	0	0	0	0	4553	4553	0.627
Portugal	0	0	0	0	0	0	0	0	3982	0	3982	0.549
Bahrain	580	128	84	86	149	169	362	995	618	85	3256	0.449
Poland	0	0	0	0	0	126	105	0	0	2304	2535	0.349
Singapore	0	0	0	0	100	0	0	0	0	2030	2130	0.293
Qatar	43	0	106	86	63	107	588	746	170	128	2037	0.281
Ivory Coast	0	0	0	0	1214	0	0	0	0	0	1214	0.167
Ukraine	0	0	0	0	0	0	0	0	929	0	929	0.128
Netherlands	538	0	0	0	0	42	0	0	21	21	622	0.086
U.S.A.	0	0	0	0	0	463	0	0	0	0	463	0.064
Jordan	0	0	43	0	0	0	0	0	43	171	257	0.035
Germany	0	0	215	0	0	0	0	0	0	0	215	0.030
Yemen	0	0	0	0	0	0	150	0	0	0	150	0.021
Lebanon	0	0	0	0	0	0	0	0	108	0	108	0.015
Oman	0	0	0	0	0	0	0	65	0	0	65	0.009
Vietnam	50	0	0	0	0	0	0	0	0	0	50	0.007
Israel	0	0	0	0	0	0	0	0	0	21	21	0.003
Belgium	0	0	0	0	0	0	0	0	0	21	21	0.003
Cyprus	0	0	0	0	0	0	0	0	21	0	21	0.003
Others	832	14783	5011	27364	169	443	190	0	212	296	49300	6.792
Total	**102159**	**68471**	**58039**	**70270**	**43893**	**19510**	**40884**	**94286**	**116631**	**111677**	**725820**	**100.000**

Rice India March '97

Kerala's Coconut Output (1991 - 96) against all India

	Area ('000 ha)		Production (millions)		Productivity (nuts/ha)	
Year	Kerala	India	Kerala	India	Kerala	India
1991-92	863.06	1529	4641	10080	5377	6593
1992-93	877.01	1538	5124	11241	5843	7310
1993-94	882.29	1635	5192	11975	5885	7324
1994-95	910.96	1669	5336	12196	5858	7309
*1995-96	982.10	NA	5906	NA	6014	NA

Source : Directorate of Economics and Statistics, CMIE
* Provisional

Kerala's Pepper Output (1990 - 96) against all India

	Area ('000 ha)		Production (millions)		Productivity (nuts/ha)	
Year	Kerala	India	Kerala	India	Kerala	India
1990-91	168.51	173.48	46.80	47.95	278	276
1991-92	178.13	184.20	50.31	52.01	282	282
1992-93	183.48	189.40	49.67	50.80	271	268
1993-94	184.41	191.00	49.55	51.30	269	269
1994-95	186.72	195.10	59.26	53.10	317	272
*1995-96	190.84	NA	59.93	NA	314	NA

Source : Directorate of Economics and Statistics, CMIE
* Provisional

Wholesale Price Index

	Jan 11# 1997	Jan 4# 1997	Jan 13 1996
All commodities	319.8	319.8	297.1
Primary articles	337.8	337.7	302.4
Cereals	357.5	353.7	300.0
Pulses	454.0	455.7	400.5
Fruits and vegetables	408.6	413.0	296.2
Milk	321.0	321.0	309.9
Petroleum, crude and natural gas	133.2	132.9	130.2
Manufactured products	307.0	307.2	296.4
Sugar, khandsari and gur	239.5	240.7	241.4
Edible Oil	302.6	303.9	302.4

provisional 1981-82 = 100

Turnover of Multinationals in Catering Business in India

	Retail Sales In $ billion (1995)	No. of outlets World-wide	India	India by 2000
McDonald's	30.0	19,400	3	50
KFC	3.7	5,142	3	30
Domino's	2.7	5,180	5	100
Pizza Hut	5.3	8,883	2	30
TGI Friday's	1.0	400	1	10

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TRADE FAIRS & GET-TOGETHERS

Tentative List of Short Term Courses to be conducted by CFTRI during the Year 1997-98 [Subject to confirmation]

14.04.97 to 17.04.97	Alcoholic beverages, quality control including alcoholimetry
21.04.97 to 16.05.97	U.N.D.P. Programme on mini dhal mill
19.05.97 to 02.06.97	Fumigation, pest control and prophylactic treatment
02.06.97 to 13.06.97	Processing of cereals and pulses
09.06.97 to 13.06.97	Flour additives
16.06.97 to 27.06.97	Microbiological quality control in food processing industries
30.06.97 to 11.07.97	Meat processing
14.07.97 to 18.07.97	Analytical techniques in proteins, lipids and carbohydrates
21.07.97 to 25.07.97	Lactic preservation of vegetables
28.07.97 to 01.08.97	Detoxification of aflatoxin contaminated foodstuffs
04.08.97 to 18.08.97	Fumigation, pest control and prophylactic treatment
10.08.97 to 22.08.97	Value addition to oilseeds-interface between r&d and industry
25.08.97 to 29.08.97	Biscuit manufacturing technology
01.09.97 to 19.09.97	Technology of fruit and vegetable products
22.09.97 to 03.10.97	Post-harvest technology of fresh fruits and vegetables
06.10.97 to 09.10.97	Spices-processing, analysis and quality control
12.10.97 to 17.10.97	Preparation of sauerkrat, gerkins and other lactic fermented vegetables
20.10.97 to 31.10.97	Thermal processing of foods-principles, practices & packaging aspects
03.11.97 to 14.11.97	Processing of cereals and pulses
10.11.97 to 14.11.97	Quality control of raw materials & end products
17.11.97 to 21.11.97	Perspectives in the application of enzyme technology in food processing sector
24.11.97 to 28.11.97	Extrusion technology
15.12.97 to 02.10.98	Technology of fruit and vegetable products
22.12.97 to 26.12.97	Maintenance of refrigeration plants and machinery for processing and preservation of foods
29.12.97 to 09.01.98	Modern abbatoir practices
12.01.98 to 16.01.98	Soft drinks technology
19.01.98 to 23.01.98	Newer technology in bread making
02.02.98 to 06.02.98	Boiled sugar confections and chocolate
09.02.98 to 13.02.98	Analysis of food under food laws
16.02.98 to 27.02.98	Technology on storage, processing and quality control of foodgrains
02.03.98 to 06.03.98	Aflatoxin : Analysis in foods and feeds
09.03.98 to 13.03.98	Oilseed processing with an emphasis of indigenous technology
16.03.98 to 20.03.98	Flexible packaging of food products
23.03.98 to 27.03.98	Bakery science & technology
30.03.98 to 03.04.98	Analysis of pesticide residue
06.04.98 to 10.04.98	Workshop on approaches to flavour analysis
13.04.98 to 17.04.98	Detection, enumeration of food spoilage and food borne pathogenic microorganisms
20.04.98 to 01.05.98	Strain improvement of industrial microorganism mutation, protoplast fusion and Recombinant DNA

Minimum qualification for participation is science graduate or having experience in the respective area. For details please contact Head, Human Resource Development Department, CFTRI, Mysore - 570 013, Ph : 514310/514760 Fax : 0821-516308/517233.

ICFOST - 97

An Indian Convention of Food Scientists & Technologists, organised by the Association of Food Scientists & Technologists (India), Mumbai Chapter will be held from September 25-27, 1997 at Mumbai.

The theme for ICFOST - 97 is Emerging Trends in Food Industry in the Twenty-first Century. It will appropriately cover many topics of interest. Captains of industry, government officials, top-notch scientists, technologists and researchers from industry and academia are invited to participate in the symposium. All topics through highly experienced professionals in relevant areas such as marketing, patents and GATT regulations, food laws, newer technologies etc. will be deliberated. The symposium will also include a poster session of contributory papers from over 100 research scientists from all over the country. Some exhibition stalls at the symposium venue are planned. The AGBM of AFST(I) will be held on one of the days of the symposium.

A brochure giving details of venue, technical programmes, poster sessions, registration, advertisement tariff etc. will be brought out shortly.

For details please contact :

Dr. H. R. Adhikari

Convenor

ICFOST - 97

c/o Food and Fermentation Department

University Department of Chemical Technology

Matunga

Mumbai - 400 019

'97 China Jilin International Symposium for Corn Deep Processing

The above event will take place from August 19-22, 1997 at Changchun, China

For details, contact :

Mr. Chen Yanming,

Sr. programme Officer,

UN-aid to China Corn Processing Research & Development Centre of Jilin Province

Light Industry Design and Research Institute,

Changchun, Jilin Province, China.

Global Outlook for Food Preservation Methods and Markets

Date : 12-14 May 1997

Venue : Crystal Gateway Marriott Hotel, Arlington, Virginia, USA

The meeting is organized by Intertech Consulting and co-chaired by Dr. Mike Otterburn, Director of Chemical Research, Nabisco Inc., and Dr. Lewis Paine, President and CEO, Optal Food Ingredients, Inc.

For more details, please contact :

Jennifer Winch, Intertech Conferences, 411 US Route One

Portland, Maine 04105 USA. Tel : (027) 781-9800 Fax : (207) 781-2150.

ADVERTISERS' INDEX

AFST(I) NEWS

Bhopal Chapter

The Bhopal Chapter of AFST(I) and Central Institute of Agricultural Engineering, Bhopal jointly organised a special lecture meeting and demonstration of production of soymilk and soy*paneer* on 16.10.1996 on the occasion of World Food Day. The lecture was delivered by Dr. Krishna Jha, Senior Scientist (Microbiology), CIAE Bhopal on the topic 'Soy-based Dairy Analogs and Fermented Foods'. Also, a demonstration of *Takai Tofu* system was organised for production of soymilk and soy*paneer* at soybean Processing & Utilization Centre, CIAE, Bhopal. The special lecture meeting was chaired by Dr. N.S.L. Srivastava, Director I/c, CIAE, Bhopal. Dr. S.D. Kulkarni, Hon. Secretary, Bhopal Chapter welcomed the participants. Dr. Nawab Ali, President, Bhopal Chapter briefly introduced the programme theme. The main speaker, Dr. Krishna Jha highlighted the various aspects of production of soy-based dairy analogs and fermented foods. The Chief guest, Dr. N.S.L. Srivastava emphasised the need to rededicate for making available good quality food to poor at the cost affordable by them. Dr. S.D. Kulkarni, Hon. Secretary, proposed a vote of thanks.

On this occasion, the soy-based food products were served to participants and information on recipe etc. was made available. Demonstration of soymilk/*paneer* production was also a big attraction for participants. Over 70 participants from different organisations attended the function.

Hisar Chapter

Election of office-bearers for the year 1997 of AFST(I), Hisar chapter was held on 25th Jan. 1997 and the following members were elected.

Prof. P.C. Panda - **President**

Dr. J. L. Mangal - **Vice-president**

Dr. J. Sahoo - **Secretary**

Dr. S. S. Dhawan - **Treasurer**

Executive Committee Members :

Dr. K. Lakshminarayana

Dr. R. C. Anand

Dr (Mrs.) Kamala Choudhry

Dr. Salim Siddiqui

Dr. (Mrs) S. Sehgal

Ms. Priti Choudhury

OBITUARY

We record with deep regret the passing away of the following distinguished personalities : Dr. K.R. Sreekantiah, former Scientist, CFTRI, Mysore, former Secretary, AFST(I) a former Editor, JFST at Bangalore on 20-12-1996.

Prof. B.K. Bachhawat on 23.9.1996. He had held a number of high academic & scientific positions and was a recipient of several national awards He was also intimately associated with R&D related to foods and active in several policy making committees of the nation.

Our heartfelt condolences to the bereaved families.

Chief Editor - IFI

JFST CONTENTS

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